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REPORT

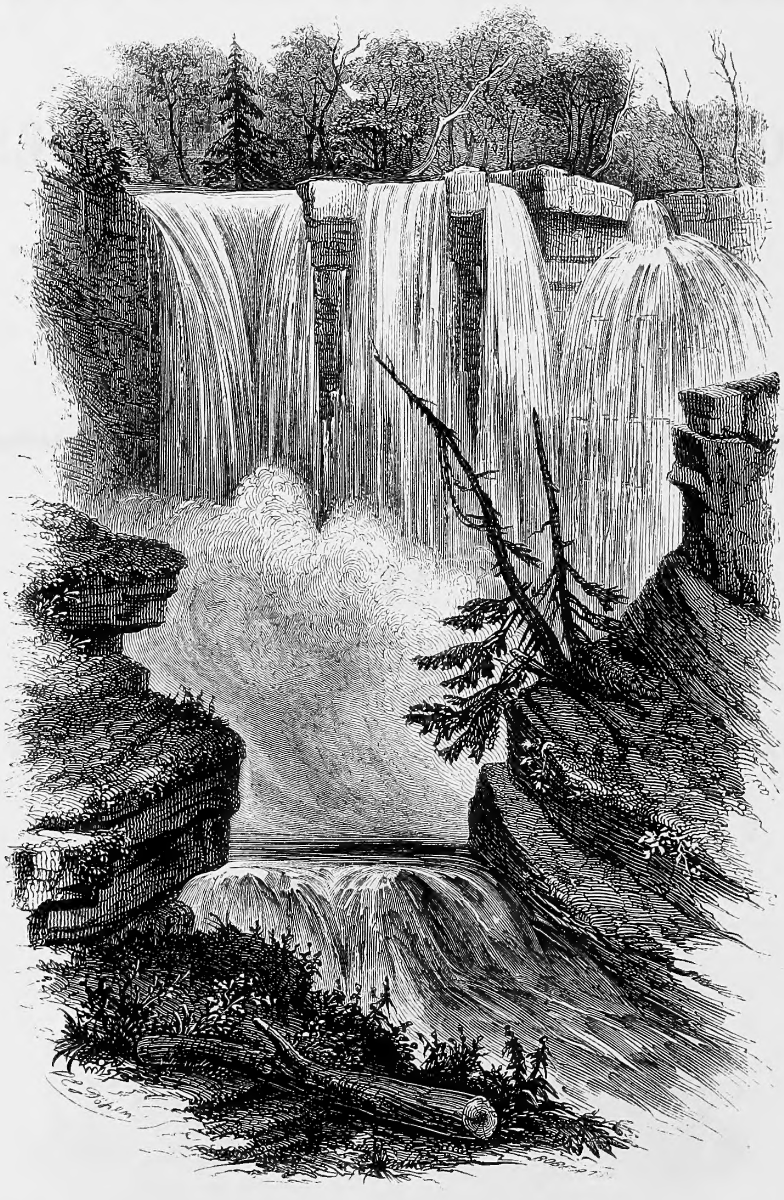
OF A

GEOLOGICAL SURVEY

OF

WISCONSIN, IOWA, AND MINNESOTA.

BY AUTHORITY OF CONGRESS.



FALLS OF PIGEON RIVER.

REPORT

OF A

GEOLOGICAL SURVEY

OF

WISCONSIN, IOWA, AND MINNESOTA;

AND INCIDENTALLY OF

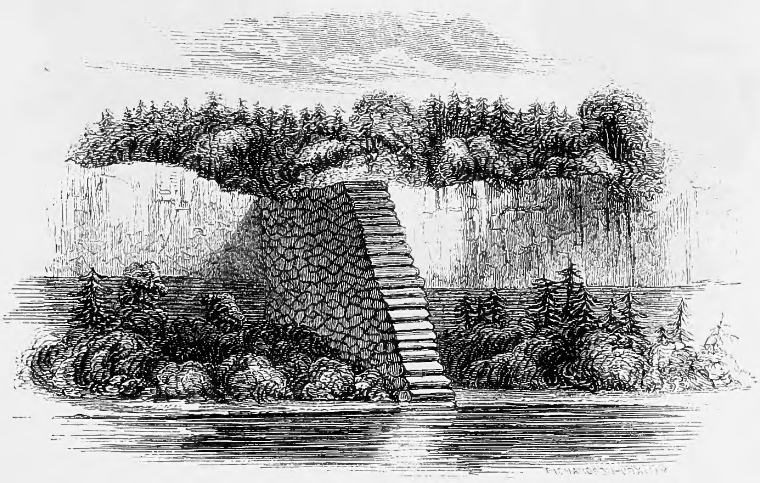
A PORTION OF NEBRASKA TERRITORY.

MADE UNDER INSTRUCTIONS FROM THE UNITED STATES TREASURY DEPARTMENT.

BY

DAVID DALE OWEN,

UNITED STATES GEOLOGIST.



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INTRODUCTORY LETTER.

TO THE HON. J. BUTTERFIELD,

COMMISSIONER OF THE GENERAL LAND OFFICE,

WASHINGTON.

New Harmony, Indiana,
October 30, 1851.

Sir :—The Preliminary Reports, forwarded by me from time to time, have furnished to the Department accounts of the field work; while the Annual Reports of 1848 and 1849, heretofore submitted, contain a more full and digested statement of the observations and discoveries of each year, made by the Geological Corps, in Wisconsin, Iowa, and Minnesota.

The Final Report, which I now lay before the Department, embraces, in a concise, connected, and revised form, the substance of all the previous reports; together with a full statement of the results of last season's operations: thus covering the entire ground of the Survey.

Condensed reports of the Assistant Geologist and of the heads of sub-corps, accompany the present Report. These contain detailed descriptions of the districts specially assigned to each; together with generalizations deduced therefrom.

In the estimation of heights, to be calculated in accordance with my instructions above the level of Lake Superior, a long series of barometrical observations became necessary. Some of these have been recorded in the form of meteorological tables, supplying materials for comparing the climate of Lake Superior with that of the Upper Mississippi, and showing the former to be milder and more equable than the latter, and, indeed, than that of many portions of the United States, in much more southern latitudes.

I may here remark, however, that it has been my aim, during the entire conduct of this exploration, to make the strictly practical and business portion of the Survey the chief end and object of our operations. Scientific researches, which to some may seem purely speculative and curious, are essential as preliminaries to these practical results. Further than such necessity dictates, they have not been pushed, except as subordinate and incidental, and chiefly at such periods as, under the ordinary requirements of public service, might be regarded as leisure moments; so that the contributions to science thus incidentally afforded, and which a liberal

policy forbade to neglect, may be considered, in a measure, a voluntary offering, tendered at little or no additional expense to the Department.

Of such a character are the researches establishing the palæozoic base in the Mississippi Valley, and bringing to light fossil remains in rocks that have been hitherto set down in the West as destitute of organic remains.*

Dr. Norwood's Report exhibits the limit, extent, and range of the trap formations on the south shore of Lake Superior, towards Fond du Lac, and also the various systems of intrusive traps, which can be traced on the north shore, up to the British line; together with detailed statements touching the mineral veins discovered over that region of country.

Colonel Whittlesey's Report traces the trap ranges, and defines the boundaries of formations on the south shore, from the Bois Brulé as far as the western boundary of Michigan.

Both exhibit the facts which finally led to the conclusion, that in this part of the Chippewa Land District, there are no copper lands, with sufficient promise of productive veins, to justify the Department in setting them apart as a mineral reservation.

Throughout this Report, abundant evidence will be found, in proof that both the Upper and Lower Magnesian Limestone formations of Wisconsin and Iowa are lead-bearing, and, to some extent, copper-bearing also. But there will be found, at the same time, the reasons which have governed my recommendation, that here, as on Lake Superior, no mineral reservations should be made.

To avoid repetition and an unnecessary increase in the bulk of this Report, I have either condensed or wholly omitted many minute details, collected by various members of the corps; which, though required to establish the bounds of formations, became superfluous after having subserved that special purpose.

I have also suppressed long lists of barometrical measurements and astronomical observations, necessary in the location and estimation of geological sections; but, that object served, never likely again to be referred to.

The local details, found at the conclusion of each chapter, will be chiefly interesting to the present settlers, or to those seeking locations in the district of country of which they treat.

The general reader will find in the Introduction, besides a narrative of events, a brief summary of the leading practical results obtained in the course of the Survey; while, to the geologist, the sections in each chapter relative to the palæontological character and mineral contents of each formation; the lithological and stratigraphical details in Dr. Shumard's Report; together with the investigations in Chapter V. touching the age of the red sandstones of Lake Superior, and the details connected

* See, for particulars, § 2, of Chapter I.

with the same subject embodied in Dr. Norwood's Report, will all possess more or less interest. So also, in Dr. Norwood's Report, will the mineralogical and orographic information, and the remarkable metamorphoses of the sedimentary strata on the north shore.

Both the general reader and the geologist will probably find interest in the incidental chapter on that extraordinary and hitherto almost unexplored region, the Mauvaises Terres (Bad Lands); a region not only attractive to the naturalist by its rare wealth of fossil remains, but, in its natural features, perhaps unique throughout the world.

In justice to those who have aided me in the Survey and in preparing materials for this Report, I here state, that, but for the industry and perseverance they brought to the task, it would be still far from completion. Our working hours have usually been twelve, sometimes fifteen, per day; and even with such exertions, it has been with difficulty we have executed the necessary analyses, calculations, diagrams, sections, and charts, so as to present the whole in its present complete form, before the opening of the approaching session of Congress.

In conclusion, I beg here to acknowledge the valuable and essential aid contributed on this Geological Survey by the following gentlemen:—

Assistant Geologist: J. G. Norwood.

Heads of Sub-corps: J. Evans, B. F. Shumard, B. C. Macy, C. Whittlesey, A. Litton, R. Owen.

Sub-assistants: G. Warren, H. Pratten, F. B. Meek, J. Beal.

I am, Sir,

Your obedient Servant,

DAVID DALE OWEN,

U. S. Geologist.

INTRODUCTION.

THE country which, during the conduct of this Survey, has been more or less carefully examined, and of which the geological features have been determined, and are, on the General Map, exhibited by colouring separately each formation, is the most extensive ever reported by any geologist or geological corps in this country; including as it does more than four times as much territory as the State of New York, and being about twice and a half as large as the Island of Great Britain.

Wisconsin, except its eastern portion on Lake Michigan, Minnesota, and Iowa, were embraced in my instructions. The Map, it will be seen, extends somewhat beyond these bounds, including a portion of Northern Illinois, and also of Northern Missouri. These additions were necessary to a proper understanding of the formations of the district expressly required to be explored; and they place before the eye, at once, as well the size and shape of the Iowa and Missouri coal-field, as its relation to that larger coal-basin, heretofore (to wit, in my Report of 1839) laid down by me as the Illinois coal-field.

With these additions, the Map reaches from latitude 38° to latitude 49°; and from longitude 89° 30′ to longitude 96° 30′. In other words, it has a length from north to south of upwards of seven hundred and fifty miles: from St. Louis to the British line; and an extreme breadth of about three hundred and fifty miles: embracing the Mississippi and all its tributaries, from its source to its junction with the Missouri; the Missouri, as high as Council Bluffs; the Red River of the North, from its source to the northern boundary of the United States; together with the northern and southern shores of Lake Superior, from Fond du Lac, north to the British dominions, and east to the Michigan line.*

The average width of the territory thus laid down being about two hundred and seventy miles, its area exceeds two hundred thousand square miles.

* The recently set off reserve, on the Mississippi, south of Crow Wing, and now ceded to the Winnebagoes, must be here excepted. Covered to a great extent with drift, without promise for the geologist, and likely to remain Indian property, its examination would have been little valuable to science, and useless to the Department.

Throughout this vast district, all the principal streams which water it have been explored, to the number of ninety-one, and more than a fourth of these have been navigated from their mouth almost to their source, in bark canoes. The streams are:

*Wisconsin.
Kickapoo.
Barraboo.
Muscle.
Bad Axe.
Raccoon.
*Prairie à la Crosse.
Black.
*Mountain Island.
Buffalo (Beef).
*Chippewa.
L'Eau Gallée.
*Miskwagokag (Red Cedar of the Chippewa).
L'Eau Claire.
*Manidowish.
*Courtoreilles.
Lac du Flambeau.
*Rush.
*St. Croix.
Kinnikinick.
Willow.
Apple.
Sunrise.
*Snake.
*Kettle.
*Nemakagon.
*Rum.
Mud.
West Savannah.
*Turtle.
Wabizipinican.
Des Moines.
Raccoon Fork.
Skunk.
Iowa.

*Red Cedar.
Otter.
Lime.
Shell Rock.
Turkey.
Upper Iowa.
Hokah (Root).
Miniska.
Wazi-oju.
La Hontan (Cannon).
Vermilion (of the Sioux).
Minnesota.
Mankato (Blue Earth).
Lesueur.
Waraju.
Crow Wing.
*Leaf.
*Red River of the North.
Ondadawanonan.
*Rainy Lake.
*Big Fork.
*Vermilion (of the Chippewa).

SOUTH SHORE OF LAKE SUPERIOR.

Montreal.
Mashkeg.
*Mauvais (Bad).
Miskwimin (Raspberry).
Mishkegomineka (Cranberry).
Poplar.
Aminekan.

*St. Louis.
Left Hand.
Muckodé (Black).
*East Savannah.
Embarras.

NORTH SHORE OF LAKE SUPERIOR.

*Kinechigakwag.
Passabika.
Mokoman (Knife).
Manissisug (Rivière des Français).
Menissingk (Encampment Island).
Passabikissingk.
Kanokikopag.
Kagishkensikag.
Palisade (Baptism).
Manitowashiwi.
Kinewabik.
Nizhwakwindeg (Two Island).
Inaonani.
Kawimbash.
Kamanosisatikag (Aspen).
Oquinekan (Roseberry).
Kagishkingwa (Cut Face).
Wisacodé (Burnt Wood).
Omimi (Pigeon).
Namobin.

Three Rivers.
Nishnabatona.
Missouri.

An inspection of the Map will give a better idea of the relative size and position of the various formations throughout the district, than could any description by

* All those marked with an asterisk have been navigated from their mouth to their source, or nearly so.

metes and bounds. The Lower Sandstones (lowest protozoic strata) will be seen coming to the surface on the east side of the Upper Mississippi, north of the Wisconsin River. They doubtless underlie, also, the extensive drift and the Red Marls and Clays, of the Lake Superior country; there assuming a red tint and ferruginous, argillaceous character.

To these succeeds the Lower Magnesian Limestone, which appears on both sides of the Upper Mississippi, southwest of the Lower Sandstones, and partially intersected by narrow belts of the same, where they crop out beneath it, in the deep cuts of the streams, or rise to the surface along the bearings of partial axes of upheaval.

Next supervenes the Upper Magnesian Limestone, with its underlying shell-beds, its lead-bearing strata, and its coralline and pentamerus subdivisions: all lying south of the two preceding.

Southwest, again, we come upon the Cedar Limestones, cotemporary with the Devonian formation of English geologists; separating the Magnesian Limestones of the north from the Carboniferous Limestones and the great coal-field of Iowa and Missouri.

The intervening country, lying chiefly towards the head waters of the Mississippi and its tributaries, and on Red River, is overspread with drift. The latter occupies, in this district, not only a much greater area than any one of the above described formations, but nearly as much as all of them put together.

Underlying the whole of these formations, but showing themselves only over limited tracts, either in cuts of the streams, or where they protrude in dikes or ridges upheaved by igneous action, are the crystalline and metamorphic rocks.

The geological formations of the district proper range, therefore, from the granite to the top of the coal-measures; above which latter, except superficial deposits, no geological group has been detected; no New Red, whether Permian or Triasic; no Cretaceous System; no Tertiary Basin.*

Over this entire region of country (with the exception of that part of Northwestern Minnesota which lies between the British line of the north shore of Lake Superior),† it will be wholly unnecessary, hereafter, to institute further examinations having reference to mineral reservations. The fact has been reliably ascertained, that it contains no lands, which, following the usual rules adopted by the

* The cretaceous and tertiary formations incidentally noticed in this Report lie beyond the limits of the district, west of the Missouri River. It is not improbable, however, that cretaceous strata may underlie the drift in the extreme northwestern corner of Iowa, sweeping around the confines of the carboniferous limestone, east and west of the Sioux River.

† This region of country may, on closer examination, be found to contain valuable minerals, suitable for reservation. But as it is still the property of the Chippewas, no mineral reservations could, with propriety, be made; nor, as it is still undivided, even by meridian lines, were any such reservations, by metes and bounds, practicable within it.

Land Office, ought to be reserved from sale, for mineral purposes. Coal and iron, in abundance, and also other valuable minerals, have, indeed, been found, and their localities carefully determined; but it has not been customary to make mineral reservations, on behalf of the United States, except of tracts promising profitable veins of lead, of copper, or of one of the precious metals.*

The coal-measures of Iowa are shallow, much more so than those of the Illinois coal-field. They seem attenuated, as towards the margin of an ancient carboniferous sea; not averaging more than fifty fathoms in thickness. Of these the productive coal-measures are less than a hundred feet thick. The thickest vein of coal detected in Iowa, does not exceed from four to five feet; while, in Missouri, some reach the thickness of twenty feet and upwards.

In quality, the coal is, on the whole, inferior to the seams of the Ohio Valley. To this, however, some very fair beds form exceptions.

On the Mankato and its branches, several pieces of lignite were picked up from the beds and banks of the streams. Some of this lignite approaches in its character to cannel coal; but most of it has a brown colour, and exhibits distinctly the ligneous fibre, and other structure of the wood from which it has been derived. Diligent search was made to endeavour to trace this mineralized wood to its source, and discover the beds where report had located an extensive and valuable coal-field. At one point, a fragment was found seventy feet above the level of the river, projecting from the drift; but no regular bed could be detected anywhere, even in places where sections of the drift were exposed down to the magnesian limestone. The conclusion at which those gentlemen who were appointed to investigate this matter arrived, was, that the pieces occasionally found throughout the Minnesota country, are only isolated fragments disseminated in the drift, but that no regular bed exists within the limits of the District.

The occurrence of strata of brown coal, earthy coal, and bituminous coal, and shale, on the west side of Great Bear Lake, as reported by Dr. Richardson, overlying a vast region of magnesian limestone, like those of Iowa and Wisconsin, rendered it possible that this lignite might be found in partial beds also on the Mankato; nevertheless, the observations of the sub-corps on that stream do not leave any hope of the existence of even such local carbonaceous deposits. On the contrary, it appears most probable that the pieces found have been transported from the north along with the drift, perhaps from these very beds on Great Bear Lake, or from the cretaceous or supercretaceous lignite formations which were observed by Nicollet, and others, off toward the Missouri and Rocky Mountains.

* A rich vein of lead ore, traversing the Lower Magnesian Limestone, was discovered on the "Half-breed Tract," south of Lake Pepin; but this being an Indian cession, it was not reported to the Department, for reservation.

In further support of this view of the origin of the lignite of the Minnesota country, I may add, that every piece, and fragment which the members of the sub-corps could find, was collected and brought away, all of which, when put together, and weighed, did not exceed ten pounds.

From the confluence of the War-oju, to the mouth of the Red Wood River, which is as far up as the country was explored, different varieties of crystalline rocks, alone, make their appearance, varying in height from a few feet to a hundred and twenty-five feet. After passing Little Rock, twelve principal exposures are seen immediately on the bank of the river in the distance of eighty miles, the intervals being covered by alluvium and drift, which hides them from view. The principal varieties are granites, and hornblendic rocks, with occasionally syenite. No traces of metallic veins worthy of note were observed traversing these formations. In the granite, eight miles below the mouth of the Red Wood River, some specular iron was found, but only in thin crusts in the joints of the rock.

The only mineral that promises to be of much value in this region of country, is a bed of nodular iron stone, found at a number of localities, both on the Mankato and Lesueur Rivers, at the base of the drift, resting either on the magnesian limestone or sandstone. This argillaceous bed of carbonate and hydrated brown oxide of iron, varies from one to three feet in thickness.

The middle division of the Iowa coal-field affords, at many localities, iron stones of various qualities, associated frequently with hydraulic calcareous cement, which occurs either in the form of disconnected *septaria* or regular beds. In the same geological position, at many localities, crystallized selenite has been observed, which accumulates in quantity high up on the Des Moines; and, finally, a few miles below its Lizard Fork, that mineral expands itself into heavy beds of gypsum or plaster of Paris, which show themselves on both sides of the river for the distance of about three miles, exposed in horizontal beds with a thickness of from twenty to thirty feet.

The iron-stone occurs sometimes in the form of concretionary nodules, sometimes in continuous bands of several inches in thickness, interstratified in the shales. In the chapter embracing the detailed descriptions of the carboniferous rocks of Iowa, will be found the analysis of some of this iron ore, together with other more precise information regarding it.

On Soap Creek and its branches, in Davis County, where the middle division of the coal series prevails, there are several salt springs, which were tested qualitatively on the spot, and found to contain a portion of common salt (chloride of sodium). The amount of the precipitated chloride of silver, as well as the taste of the water, indicated, however, only a weak brine. By boring, a stronger water might possibly be obtained; nevertheless, the shallowness of these coal-measures, the frequent

rupture of the strata and consequent local reversion of the dip, together with the fact of the lowest division being composed chiefly of limestone instead of sandstone, are unfavourable indications of the existence of a plentiful supply of deep-seated brine, or of nests of salt, whence the permeating waters might become saturated, and carry the saline matter to the surface.

Though deficient in productive minerals, such as are reserved by the Land Office, a large proportion of this District consists of rich, fertile soil, well adapted to all agricultural purposes. Of such is a large portion of the Iowa coal-field; and the region lying north both of that and of the Illinois coal-field, as far as the Falls of the eastern tributaries of the Mississippi. Some of the lands of the Des Moines and Cedar Rivers can be scarcely excelled for fertility, perhaps, in the world.

On the other hand, there are portions of the District, chiefly in the vicinity of the sources of the Black and Chippewa Rivers, and of the streams flowing north into Lake Superior, which are, in part, so hopelessly arid, that, in our generation, they will assuredly never be purchased or occupied; in part so covered with erratic boulders, that the traveller can step from one to the other, for miles, without setting foot on the drift-soil on which they lodge, and that a bridle-path for a pack-horse cannot be picked out over the country they cover; in part, again, so intersected by countless ponds and swamps, that fish, frogs, and water-fowl must, in our day at least, be their only inhabitants.

In conformity with my instructions, I have heretofore, from time to time, reported to the Department what portion of these lands are so wholly worthless, as not to justify, in my judgment, the expense of sectionizing, or of surveying at all, except so far as may be necessary to connect the surrounding surveys. These refuse lands amount to upwards of fifteen thousand square miles. If, in consequence of the recommendation thus made, they are excepted from the linear surveys, which are usually extended, by the Government, over all its Indian purchases, without examination or inquiry, the saving to the Land Office will much overpay the entire cost of the survey, the results of which I am now reporting.

A circumstance which to some may seem trivial, will delay, to a considerable extent, the settlement of a portion of the District. It is the prevalence, especially on the Upper Wisconsin, Chippewa, St. Croix, and Black River countries, and thence north to Lake Superior and to the British line, of venomous insects, in such insufferable quantities, that, at certain seasons, they destroy all comfort or quiet, by day or by night. Among the pineries of Northern Wisconsin, and more or less throughout the whole of the above designated region, the buffalo-gnat, the *brulot** and the sand-fly, to say nothing of myriads of gigantic musquitoes, carry on incessant war against the equanimity of the unfortunate traveller. I and other members of

* So called by the voyageurs from *bruler*, to burn; the sting producing a burning sensation.

the corps, when unprovided with the necessary defence, have had our ears swelled to two or three times their natural size, and the line of our hats marked, all round, by the trickling blood. It was often necessary to rise many times, in the course of the night, to allay the fever of the head, by repeated cold bathings; and, at some of the worst spots, we could scarcely have discharged our ordinary professional duties at all, without the constant protection of musquito-netting, worn over our head and face.

The health, even of the more marshy portions of the District, seems better than, from its appearance, one might expect. The long, bracing winters of these northern latitudes exclude many of the diseases, which, under the prolonged heat of a more southern climate, the miasm of the swamp engenders. Perhaps the healthiest portion of the whole District, is along its northern limit, where it is coterminous to the British dominions. At the Pembina settlement, owned by the Hudson's Bay Company, to a population of five thousand there was but a single physician; and he told me, that, without an additional salary allowed him by the Company, the diseases of the settlement would not afford him a living.

Our own party occasionally suffered severely from sickness, consequent upon exposure amidst almost impassable swamps. In 1849, not a single member of my corps escaped obstinate intermittents. In 1848, Dr. Shumard was attacked with a severe pleurisy, high up on the St. Peter's, beyond the reach of all medical aid. His life being in great danger, he was received, for a few days, into the mission house, at Traverse des Sioux, where the missionary, Mr. Hopkins, gave up to him his bed, and treated him with the utmost kindness. He was then run down the river, day and night, in a canoe, to Fort Snelling, where Captain Eastman, of the U. S. Army, stationed at the fort, assigned to him, during his illness, apartments in his own quarters. To the hospitable care of these two gentlemen and their families, Dr. Shumard probably owes his life; and I take pleasure here, in tendering to them, on his behalf, his most grateful acknowledgments.

Mr. B. C. Macy, in tracing the confines of the carboniferous formation between the Iowa and Cedar Rivers, penetrated a region of ponds and swamps, through which he waded, under a burning July sun, for many days, and contracted an obstinate and dangerous intermittent, from the effects of which his health, even now, after two years, has scarcely recovered.

We lost, by death, but one man, of cholera, at Muscatine, in Iowa, in July, 1849. Throughout the whole of that season, as the cholera was very prevalent over the region of country we were surveying, we had great difficulties in inducing voyageurs to risk the exposure of our trips, and had to offer extra pay, in order to obtain their services at all. Gobert, the man we lost, was attacked while we were getting our goods into the warehouse at Muscatine, about one o'clock in the day. We could not persuade the tavern-keeper to receive him into his house; but we obtained, not

without difficulty, the shelter of the warehouse, where we made him as comfortable as the circumstances permitted, and used every means in our power to save him; ineffectually, however, for he died about four o'clock next morning.

In the category of accidents that befell us that year, is to be included one, which came near having a fatal termination. It occurred while I was ascending the Upper Des Moines. Our bowsman (as the voyageur who manages the bow paddle is called) having discharged his rifle at a deer, had reloaded it, and, in the excitement of the chase, had hastily laid it down beside another gun, on the forward thwart of the canoe, with the muzzle imprudently pointing, in a direct line, towards myself; I being seated, with Mr. B. C. Macy, in the centre of the canoe. A sudden jerk of the boat caused the discharge of the rifle. Had not the breech of the other gun chanced to lie slantingly across the muzzle of the discharged piece, this Report, in all probability, would have been completed by some one else than its present author. As it was, the ball struck the brass mounting of the other piece, which, together with the stock of the gun, it shattered to pieces, being itself split up into several fragments, and diverted from its original direction. Of the fragments, three passed through, and severely lacerated, the deltoid muscle of my left arm; and two others, probably portions of the mounting, wounded Mr. Macy; one, pretty badly, on the cap of the knee, and another, which was afterwards extracted, on the face. Besides these, both of us received several slighter wounds; the coat which I wore being perforated by more than a dozen holes. No more serious consequences, however, resulted, than that Mr. Macy, for many days, could scarcely step in or out of the canoe, and that I was disabled for a few weeks.

The next year, my principal assistant, Dr. Norwood, came very near losing his life, like Dr. Houghton, on Lake Superior. One of those sudden squalls, so common on that sea-like body of water, arose, while the party, in their bark canoe, were at some distance from shore. Before they could effect a landing, the waves already ran so high, that the voyageurs were unable to manage the light bark, which was dashed on shore and broken to pieces; all the party, however, escaping with their lives.

There is a risk, against which all surveying parties, whether geological or linear, would do well, in such a country as this, carefully to provide; as unforeseen and unexpected delays, at portages and elsewhere, sometimes of necessity occur: it is the failure of provisions. We have frequently, notwithstanding the utmost prudence, exhausted the last pound of eatables, and travelled a day or more, without breaking our fasts. On one occasion, a single pigeon supplied a corps of three men during three days; but only one of my company was ever reduced to the same extremity as a party of United States linear surveyors, who, when running a meridian line, reached Lake Superior in a state of exhaustion and emaciation from hunger, which disqualified them, for some time, from proceeding with their work.

The danger from this source becomes imminent, if the explorer, unprovided with an experienced guide, happens to lose his way. It is hardly necessary here to warn the inexperienced, as so many Western travellers already have done, how readily, in these wild regions, this may occur. I will here mention but a single instance, that of one of my assistants, travelling alone in the country north of Lake Pepin, who, deceived by an incorrect map, mistook the Kinnikinick for Rush River, missed, in consequence, a deposit of provisions left for him on the Eau Gallée, travelled three days without other food than a few wild berries, and was relieved, at last, in a state of complete exhaustion, by the tenant of a solitary cabin, which he discovered soon after striking the Mississippi, above Lake Pepin.

In 1848, though we had not the cholera to contend with, I found, on one occasion, even greater difficulty in procuring voyageurs than during the prevalence of the epidemic. This occurred in consequence of my determining, soon after reaching the mouth of Crow Wing, in June of that year, to descend the Red River of the North, a resolution adopted from the following considerations.

The appearance of the country between the Falls of St. Anthony and Crow Wing, did not augur well for facilities of observation in developing the geology of the district which lay before us to the north. After conversing with several of the Indian traders, who had just arrived at the Crow Wing post, with furs from their respective stations in the interior, I became convinced that the only practicable method of gaining an insight into the geology of the northern portion of the Chippewa Land District, was to shape my course along the deep cuts of the great valleys. On consulting the maps of the territory we were about to enter, it was evident that the channels of the Mississippi, Red River of the North, and St. Louis River, together with the basins of the great lakes, afforded the best prospect of throwing open to our view sections of rocky beds, if such existed accessible to observation.

To the assistant geologist, Dr. Norwood, I therefore assigned the duty of examining the valleys of the Mississippi and St. Louis Rivers, Red Lake, Leech Lake, Cass, Winibigoshish, and Vermilion Lakes, as well as a part of the north shore of Lake Superior.

With my own corps I decided to ascend Crow Wing River to Leaf River, a branch coming in from the west, to follow up that stream, and, by a series of small lakes and intervening portages, to gain Otter Tail Lake. Thence I proposed to enter Red River, descend its channel to the United States line, and proceed thence to the Selkirk colony, for the purpose of procuring a fresh supply of provisions. From this settlement I proposed to reach the Lake of the Woods and Rainy Lake by the most feasible route, and on my way back to the Mississippi, make a reconnoissance of that part of the north shore of Lake Superior not included in Dr. Norwood's route.

The country through which I thus purposed reaching the British dominions, was comparatively unknown. It is true, that Major Long and his party had, as early as 1823, descended a considerable portion of the valley of Red River, not very far from part of the line of route we proposed to ourselves. The knowledge, however, which that expedition furnished regarding the geology of Red River amounted but to this,—that there existed a secondary calcareous formation, which they found in place near the settlement on Red River, and at another locality on the shore of Lake Winnipeg; which limestone, they conjectured, might underlie the prairie country. But, in the present state of geological knowledge, the fact of there being a secondary limestone at one or two points over a country larger than the whole State of New York, conveys but very imperfect information. At the period when Mr. Keating made his observations on that expedition, the science of Geology was, comparatively, in its infancy; and he did, doubtless, for his time, as much as could be expected. In our day it is necessary, in order to convey a definite idea of the sedimentary formations of a country, to identify them with some familiar group or system that has been minutely studied on some other portion of this continent or Europe; the contents of which—minerals as well as fossils—have been carefully observed.

To determine, then, to which of these systems the calcareous rocks of Red River belonged, was one object I had in view. Was it a member of the same system of magnesio-calcareous formations that we had traced, in 1847, over so great an area in the southern portion of the Chippewa Land District? Some further light upon the subject I am now able to furnish, though the nature of the country was such as to offer to me no very numerous opportunities, beyond those enjoyed by my predecessor, of gaining access to beds *in situ*.

A portion of the route selected lay, indeed, beyond the boundaries of the District which I was instructed to explore. Since, however, it was the deep-cut valley nearest to the western frontier of the Chippewa Land District, and since we were compelled, in order to obtain supplies for our subsistence on our homeward route, to go on to the colony on Red River, the propriety, indeed the necessity, of the course pursued, will be apparent. No land route near the line gave any hope of accomplishing the objects in view.

Governed by these conclusions, in a few days after our arrival at Crow Wing, I proceeded to hire the necessary voyageurs. As soon, however, as the line of our proposed route became known, they positively refused to accompany us. Red River was, for them, a *terra incognita*. Not only were they themselves wholly unacquainted with its rapids, but, so far as they had heard, no white man or half-breed trader had ever descended the stream.* Add to this, that the Red River Valley

* On reaching Pembina Settlement, we learned, in effect, that but one white man was ever known to have navigated this river between Otter Tail Lake and the settlement, previous to our descent.

was not only a region of country remote from civilization, known to be uninhabited except by Indians, but noted also as a contested hunting-ground; a sort of "debate-able land," between the Sioux and their enemies, the Chippewas; the usual theatre of their forays and their battles. It was well known, also, that the Sioux had, some months before, committed certain depredations on the Chippewas; and the voyageurs feared to encounter the war-parties of the latter tribe, who, it was supposed, were then lying in wait, bent on retaliation.

After the refusal of the first engaged voyageurs, I hired another set, but with no better success. As the time appointed for starting approached, one after another was found missing, deterred by the expected dangers of the way. And I was finally obliged to leave the post, with no more effective force than a pilot, who would not promise to go beyond Otter Tail Lake, and three young, inexperienced men, whom we had brought with us from Prairie du Chien and St. Paul's, who knew nothing of the route before us, and but little more of the management of a birch-bark canoe, than did we ourselves.

Under these unpropitious circumstances we commenced our voyage up Crow Wing River. After poling up this stream for a few hours, we were hailed, from the rear, by Dr. Norwood, who had followed after to apprise us that he had succeeded, after our departure, in engaging the services of another young voyageur, who had just arrived from one of the northern posts, and who agreed to follow after us on foot the next day, so as to join us at a portage which leads to a lake on the north side of Crow Wing River. Here we promised to await him.

The whole of the next day was passed in hourly expectation of the arrival of our expected recruit; but we had the vexation of seeing the sun set without his making his appearance; and the following morning we proceeded on our route, in the full belief that he also had, on maturer deliberation, repented of his engagement. Much to our surprise, however, at eight o'clock in the morning of the next day, he emerged from a thicket on the north bank of the river, a few yards above our canoes. He had missed, as it appeared, the place of rendezvous, and had been wandering for two days in the woods bordering the river, in hopes of discovering something of us, having eaten nothing for a day and a half. After refreshing himself, he took his position in the bow of one of the canoes, and we proceeded on our journey, congratulating ourselves upon this new acquisition to our force, the rather as the young man had exhibited so much perseverance and determination in following us up thus far. Our congratulations, however, proved to be premature. When we reached the outlet from Otter Tail Lake into Red River, the point where our pilot had conditioned to leave us, the prospect of entering an uninhabited wilderness, which the Indians themselves are fain to avoid, unless prepared for war, proved too much for the young voyageur's nerves; so that, when the parting was about to take place between nephew and uncle (for it appeared that this

relationship existed between the youth and our pilot); when it came, I say, to the point beyond which there was no receding, the heart of the young man failed him, and he begged to be released from his engagement, pleading as his excuse, that when he contracted for the voyage, he was under the influence of the good cheer, customary on the arrival of a party from a distant trading post. As I was disinclined to take any one against his will, I finally consented to his discharge; and the uncle and nephew were soon wending their way to the southeast, over the prairie, carrying with them despatches to our friends, to apprise them of our welfare, and of our progress towards the north.

The anticipation of danger from the natives proved without foundation. With the exception of a small party of Pillager* Indians, whom we met ascending the upper waters of Red River in search of fish, and who sought to deter us from proceeding, by accounts of war-parties of the Sioux roaming about lower down the stream, we did not meet, for three weeks, from Otter Tail Lake to Pembina Settlement,—upwards of five hundred miles,—a single human being, red or white, nor a habitation, savage or civilized, except the bare poles of a few deserted Indian wigwams. The vast prairies through which we floated, and the narrow belts of timber occasionally fringing them, seemed without living inhabitant, except large yellow wolves, with a few bears and elk. Buffalo undoubtedly still frequent these plains, as evidenced by their deeply trodden paths, their lairs, their dung,† their skeletons, and their half-decayed carcasses; but no herds were actually seen.

The dangers from the river itself were of a somewhat more serious character, than from the savages. Without even a practised steersman, accustomed to guide a canoe in difficult water (the lack of whom, even in a river where the rapids and portages are known, involves considerable risk), we had here the additional misfortune of being wholly ignorant of the character of the stream before us; where, if anywhere, were its rapids and falls, or where its necessary portages. Its navigation, however, proved less hazardous than we expected; and, by keeping a careful look-out, we escaped without accident, except on one occasion, namely, at what, we afterwards learned, were called, by the Indians, the Falls of Red River, about sixty miles below Otter Tail Lake. Here, at a sudden turn in the river, we unexpectedly came upon turbulent rapids, the water foaming among a multitude of boulders; and to these we had already so closely approached, that our canoes could not be arrested, but shot down them with a velocity which it was impossible to

* These Indians, residing chiefly about Leech Lake, received their name from having taken violent possession of the goods of a trader, who had sought to defraud them, in bartering his merchandise against their furs. The epithet, at first bestowed as a reproach, has been, it is said, adopted by themselves; and they seem not a little proud of the incident by which they earned it.

† Called by the voyageurs *Bois de Vaches*, because often used by them, in its dry state and when wood fails, as a substitute to supply the camp fire.

arrest, and which soon ran them hard and fast among the rocks, at a spot where the water reached to the armpits of the men, who, when they jumped out into the stream, found extreme difficulty in maintaining their footing. Fortunately our young voyageurs proved remarkably strong and active, and by dint of exertions, of which men leading their hardy lives alone are capable,* they succeeded in extricating the canoes from their perilous situation, and in dropping them slowly down the most dangerous portion of the rapids, to within forty or fifty yards of the foot. Then jumping in, a very few minutes sufficed to shoot down that distance, and to unload and drag the canoes out on the bank. This was not effected, however, without considerable injury to both. One was partially filled with water, which wetted our flour, and damaged other of our stores. We considered ourselves fortunate, however, in escaping without more serious mishap.

We afterwards saw the trace, indicating the portage which the Indians are wont to make around these falls. Below them, Red River is easily navigated; no dangerous rapids occurring until it crosses the United States line.

The same cannot be said of the streams constituting our return route, from the British settlement at the mouth of Assiniboin, by the Lake of the Woods, and partly by the United States boundary line, to Fort William, on Lake Superior. The frequency of falls and rapids on this route may be judged from the fact, that we made over a hundred portages. Some of these rapids, especially on Winnipeg and Dog Rivers, are hazardous.† At many points, an error of half a canoe's length in striking a chute, or in bringing to, below it, is sufficient to swamp the canoe, and expose to great peril the lives of all it contains.

The risk, in our case, was diminished, in consequence of our good fortune in

* It is astonishing to observe what exertions the voyageurs of the Northwest are capable of making on certain occasions. On one of our expeditions a canoe, weighing two hundred and thirty pounds, was transported over the portage from Long Lake to the head waters of Bad River (a distance of nine miles), on the shoulders of *two* men. They carried it seven miles without stopping, and rested only once during the whole portage. When one considers the distance; the constrained position they have to walk in; the heat of the weather (80° Fahrenheit); the narrowness of the trail; the roots and swampy ground they pass over; the frequent turnouts they have to make around fallen trees, and even sometimes to climb over them; their power of endurance must be looked upon as extraordinary, and as enabling them to perform a feat which could only be accomplished by very robust men under long training. It is said that some of the *engagés* will carry from four hundred to five hundred pounds on their backs a distance of one thousand yards.

† "The navigation of this stream (the Winnipeg) is frequently attended with fatal accidents, and the number of wooden crosses we observed, at some of the rapids, are the brief mementos erected by the survivors, to the memory of the shipwrecked voyagers."—*Long's Second Voyage*, p. 89.

"Over the falls, eagles and hawks soar high in the air, watching for the easy prey which they derive from the numbers of fish that are wounded or killed by being hurried against the rocks by the irresistible force of the current."—*Ibid.*, p. 96.

obtaining, at the Assiniboin colony, one of the most experienced pilots of the settlement. And here it behooves me to acknowledge the aid and kindness we received at the hands of the Governor and British officers at that post.

Before starting on the expedition, I had obtained from Mr. John F. Crampton, of the British legation at Washington, a letter commending me to the good offices of the officers of the Hudson's Bay Company, and which procured for us a most hospitable reception at the settlement.

On our arrival at the mouth of the Assiniboin, Governor Christie, then acting as Superintendent of Affairs of the Hudson Bay Company and Governor of the Colony, invited us to make his house our home, during our stay on Red River, and entertained us in the kindest manner. I have to acknowledge the attentions paid to our party by the officers stationed both at the Upper and Lower Forts.

Governor Christie aided us, by every means in his power, as well in procuring a fresh supply of provisions, as in recommending to us the men best qualified to manage a canoe, and to guide us over the difficult and dangerous return route upon which we were about to enter.

While detained at the Assiniboin Colony by these preparations for our return, I had an opportunity of making a short visit, which pleased me much, to a settlement of about five hundred Cree Indians, residing below the colony, at Prince Rupert's Landing. They are decidedly the most civilized tribe which I have seen or heard of in the North. These Indians support themselves mainly by the produce of their farms, which they cultivate with their own hands. They dwell in comfortable, squared-log buildings, erected, thatched, and whitewashed by themselves. They are acquainted with the use of the simpler farming utensils, and the mechanical operations necessary to keep their farms and houses in order. Each family cultivates from five to ten acres of land, which is kept well fenced. They mow their own hay, and feed their cattle on it in the winter. A few occasionally hunt during a month or more in the summer, when their crops do not require much attention; but this is more for recreation than for support. Some of the men occasionally contract with the Hudson Bay Company to transport their goods to and from York Factory on Hudson's Bay.

The remarkable change in the habits and customs of these Indians has been wrought mainly through the force of example, by Mr. Smithhurst, who resides among them as missionary, and who is thoroughly conversant with their language. That gentleman is remarkable for his love of order and arrangement, and is devoted to agriculture and horticulture. His house is situated in the midst of a delightful little flower-garden, kept in beautiful order, with flourishing fields of grain and meadows in the rear. The Indians, having continually before their eyes so pleasing and practical an example of the comforts of a civilized life, as well as an illustration of the means by which, in a rigorous climate, they may be enabled to provide

for themselves a support far more stable and certain than that derived from the chase, have gradually fallen into the habits of their instructor, and, by degrees, have gathered around their permanent homes the implements and appurtenances, and even some of the comforts and luxuries, belonging to the establishment of the thrifty farmer. It is true, they are sometimes accosted contemptuously by their neighbours, the Chippewas, and ridiculed as earth-worms and grubs; but they now retort upon them: "Wait till the winter sets in, and then you will come to us, beggars for our refuse potatoes and indifferent peas."

The evening we were there, several young lads were engaged in sharpening their scythes, preparatory to going out, next morning, in a party, to mow.

The general agricultural character of the Red River country is excellent; the land highly productive, especially in small grain. The principal drawbacks are occasional protracted droughts, during the midsummer months, and, during the spring, freshets, which, from time to time, overflow large tracts of low prairie, especially near the "Great Bend." Its tenacious subsoil insures its durability.

Under the head of Agricultural Character, in each chapter of this Report, a somewhat detailed statement of the capacity for farming purposes of each separate division will be found. I may say, here, generally, that each of the distinct geological formations of this District, as laid down on the General Map, imparts to the overlying soil a peculiar character, and divides the country into as many agricultural districts.

The land best adapted for wheat and most small grains, and in which the proportion of earthy, saline, and organic matter is distributed in the best proportion to impart fertility and durability, is the soil based on the calcareous and magnesio-calcareous rocks, and which particularly characterizes the country bordering on the Mississippi and its tributaries, between the 41st and 45th degrees of latitude, with an average width of twenty to thirty miles west of the Mississippi. It includes, besides the Dubuque and Mineral Point Districts of the survey of 1839, the lands on the east side of the Mississippi, watered by the Kickapoo, Bad Axe, and Raccoon Rivers; the lower portion of Prairie à la Crosse, Mountain Island, Chippewa, Hay, Rush, Kinnikinick, St. Croix, Willow, and Apple Rivers. On the west side of the Mississippi, the country watered by the Des Moines, the two Iowas, Yellow, Root, Miniska, Wazi-oju, Cannon, and Vermilion.

East of this tract, a belt of second-rate—often poor second-rate, sandy land, stretches from southeast to northwest, nearly parallel to the preceding, with an average width of twenty-five to thirty miles. This variety of soil is nearly coincident with the outcrops of lower protozoic sandstones, from the disintegration of which it has been derived, and which imparts to it a siliceous and porous character.

So far as the comparative analysis of the soils of these two Districts has been

carried, it indicates that in the soil of the sandy region there are sixteen per cent. more insoluble silicates, seven per cent. less saline matter, 0·79 per cent. less calcareous matter, and six per cent. less organic matter, than in the calcareous district; amounts which evidence a great superiority in the quality of the latter over the former.

Through the drift region, occupying the interior of the Chippewa Land District, in Wisconsin, and especially in the pineries, the soil partakes, to a considerable extent, of the same siliceous character. Where the intrusive rocks reach the surface, it has been modified and improved by more fertilizing saline intermixtures. A large proportion of this District, especially towards the summit levels, is interspersed by lakes, morasses, and bogs, and around these the lands are generally too wet for cultivation, except under an expensive system of drainage, which cannot be expected to be undertaken in a new country where good land is so easily obtained.

The Lake Superior country presents four principal varieties of soil: a drift soil, similar in its ingredients to that just mentioned; a red clay and marly soil, prevalent over the high plains bordering the coast, and the corresponding lands on the adjacent islands; a trap soil, of limited extent, near the foot of the igneous outbursts, and finally, alluvial bottoms, which are confined almost exclusively to a small body of land on the east fork of Bad River.

The drift soil prevails through the high lands, elevated six hundred to one thousand feet above the level of the lake; also over the high grounds of the promontory, west of Chegwomigon Bay, at a height of three hundred to six hundred feet, and the higher points of the neighbouring Apostle Islands. These lands, owing to their inferior siliceous soil, and the abundance of erratic blocks disseminated over them, are hardly fit for cultivation.

The trap soils, which support a growth of sugar maple, oak, and other hard woods, are next in richness to the alluvial lands. They are found chiefly on high ridges and slopes, which, at the east and west ends of the District, are only a short distance from the lake shore; but on the waters of Bad River and the Brulé, they recede three-fourths of the distance back towards the sources of their various branches.

With these trap soils of the Lake Superior country, may be classed the lands in the vicinity of Big Bull Falls, and south of Beaulieau's Rapids, on the Wisconsin River; the Pokegoma country, bordering the lake of the same name, in Minnesota; the immediate vicinity of the Falls of St. Croix; and a portion of the Snake, Kettle, and Little Rock River country: since the soil at these localities originates from rocks of similar composition.

The red clay and marl lands, occupying the high plains skirting Lake Superior, are characterized particularly by the predominance of oxide of iron, from which they derive their colour, and which amounts to four and a half per cent., or nearly one-half of the weight of the saline matter; it is always a retentive soil, from the abun-

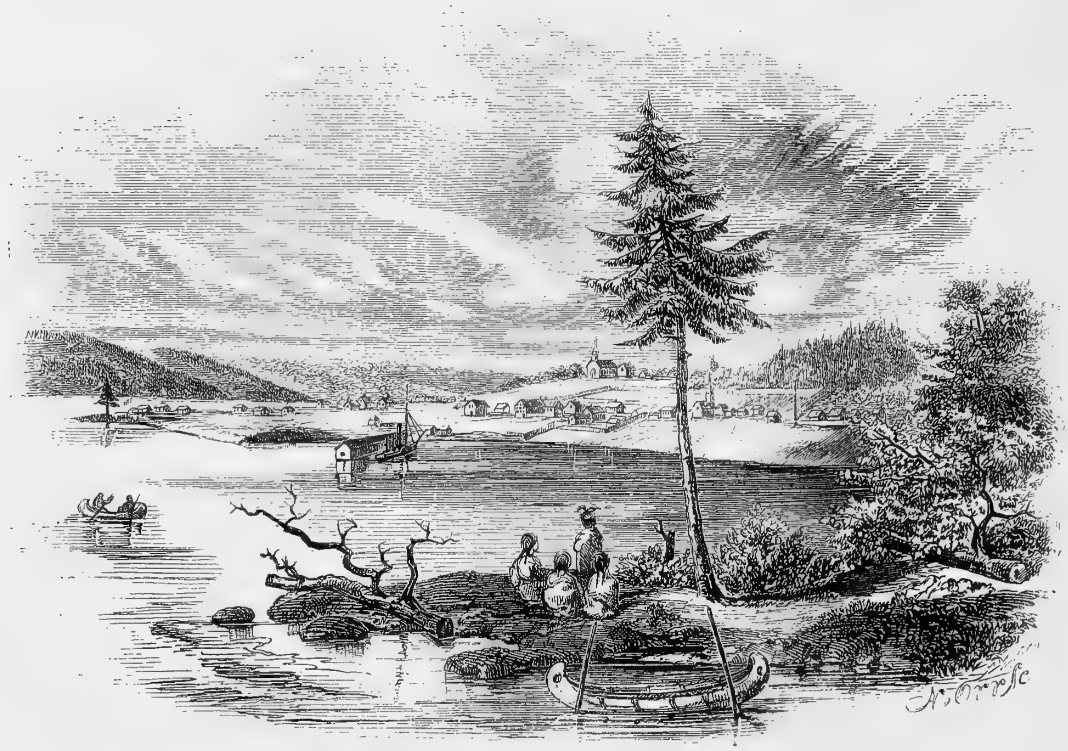
dance of argillaceous earth which enters into its composition; hence, these red clay and marl lands are often wet, particularly when defended from the direct rays of the sun, by the dense growth of cedar, balsam, spruce, birch, and hemlock that usually covers them. Still, these lands are not so wet, but that by clearing and a judicious system of husbandry, they would soon become sufficiently dry for most kinds of crops and garden vegetables. They may be compared in quality to the red lands of Maryland and Virginia, which border the Potomac River, in Montgomery and Loudon counties, which, by deep sub-soil ploughing and a proper system of drainage, produce wheat crops that can hardly be excelled. The principal drawback to bringing these lands into cultivation is the difficulty of clearing off the forest, which in many places is exceedingly dense, and the fallen timber of a character little subject to decay. The larger portion of the Lake Superior basin is occupied by these red clay and marl lands. They comprise the extensive plains of the Bad River country, and extend from near the coast to the conglomerate and trap hills, which bound them on the east and south, and which trap range, by reason of its southerly curve, from the Michigan boundary line towards Long Lake, circumscribes, in connexion with the drift ridges of Chegwomigon Bay, a semicircular area, the radius of which will average about twenty-two miles, and contains about twenty-four or twenty-five townships of land. Also, a strip of coast between Apukweyaka and St. Louis Rivers, averaging about six miles in breadth from north to south, and including about six townships, besides a small triangular area of a few sections running up the valleys of Cranberry and Siscowet Rivers; also a small area on the Apostle Islands, which will probably not exceed two or three townships more. The general elevation of the red clay plains above Lake Superior is about two hundred feet. They are, for the most part, level, with a gentle slope towards the lake, cut, however, into deep, abrupt gullies in the immediate vicinity of the streams.

The appearance and outline of a portion of the south shore of Lake Superior, is accurately delineated in the following cut, after a sketch executed, at request, by Aindi-bi-tunk, a full-blooded Chippewa Indian. It was taken from a promontory of Madeline Island, and exhibits, in the foreground, the magnificent bay, along the shore of which the beautiful village of La Pointe has sprung up.

This bay is nearly three miles across, and is capable of containing, at anchor, secure from all winds, a numerous fleet of the largest class vessels. La Pointe was originally selected by the adventurous traders of the Northwest Fur Company, as the most eligible site for a depôt and trading-post in the Northwest Territory; and was, for a long time, their principal rendezvous, and the centre of their extensive and wide-spread operations. It is not only one of the most commanding and accessible situations on Lake Superior, but it presents one of the most agreeable and picturesque lake scenes the tourist can well imagine.

Lake Superior has, at times, not only the varied interest, but the sublimity, of a

true ocean. Its blue, cold, transparent waters, undisturbed by tides, lie, during a calm, motionless and glassy as those of any small, secluded lake, reflecting, with perfect truth of form and colour, the inverted landscape that slopes down to its smooth, sandy beach. But when this inland sea is stirred by the rising tempest, the long sweep of its waves, and the curling white-caps that crest its surface, give warning, not only to the light bark canoe, still much used along its shores, but also to sloop and schooner and lake steamer, to seek some sheltering haven. At such times, craft of every description may be seen running before the wind, or beating up against it, all making for the most favourite harbour on the lake,—the sheltered bay of Madeline Island.



As a site for a town, and especially as a place of resort for health and pleasure, La Pointe offers advantages beyond any portion of the mainland in Wisconsin. Its surface is sufficiently level and extensive for all purposes of agriculture; its soil, a retentive red marl, is capable, under a proper system of tillage, of returning to the husbandman a hundred-fold, and of producing fruits and vegetables in perfection. Its gently sloping sandy beach insures a secure footing to the bather. As a fishing station, it is unrivalled. The bays and creeks of the numerous islands and main shore, distant only a few hours' run, are amongst the best fishing-grounds on the whole lake, for trout, siscowet (*Percopsis guttatus*), and white-fish or lake shad (*Coregonus albus*).

Tempered, as well in summer as in winter, by the vast expanse of water which surrounds it, and which, except at the immediate surface, is almost always at 40° Fahrenheit, its climate is milder, at once, and more equable, than any part of Wisconsin, whether it be on the mainland of Lake Superior, or further south on the Mississippi. Chiefly for this reason, but also on account of the bracing winds that sweep across the lake, Madeline Island is probably not surpassed, in point of health, by any locality throughout the entire Western country.

The prairie country, based on rocks belonging to the Devonian and Carboniferous Systems, extending up the valleys of the Red Cedar, Iowa, and Des Moines, as high as latitude 42° or 42° 31′, presents a body of arable land, which, taken as a whole, for richness in organic elements, for amount of saline matter, and due admixture of earthy silicates, affords a combination that belongs only to the most fertile upland plains.

Throughout this district, the general levelness of the surface, interrupted only by gentle swells and moderate undulations, offers facilities for the introduction of all those aids which machinery is daily adding to diminish the labour of cultivation, and render easy and expeditious the collection of an abundant harvest. There are, it is true, limited spots, less desirable for farming purposes, where the ground is liable to be overflowed by the adjacent streams, in times of freshets, and where local geological causes operate to alter the composition of the soil; or where, from too uniform a flatness of ground, near the sources of streams, water stagnates; these form, however, but a small fraction of the whole.

The greatest drawback to the settler in these portions of Iowa, is the limited extent of timber, which is chiefly found in belts and groves lining the borders of rivers, gradually diminishing in quantity, as a general rule, towards their heads. This disadvantage is in part counterbalanced by the ease with which a farm can be commenced and brought under cultivation.

Nevertheless, with proper economy and a little forethought, an ample supply both of fuel and fencing timber, may, in most instances, be insured. Again, the great extent of the coal district, throughout a large area of this prairie country, renders the consumption of timber for fuel unnecessary.

The portion of Iowa which is most deficient in timber is north of latitude 42°, especially on the dividing ridges. North of this latitude, between the head waters of Three and Grand Rivers, there are distances of ten or fifteen miles without any timber; while between the waters of Grand River, the Nodoway, and the Nishnabotona, the open prairie is often twenty miles wide, without a bush to be seen higher than the wild indigo and the compass plant. The soil, too, in this region, is generally of inferior quality to that south of latitude 41° 30′.

After passing latitude 42° 30′, and approaching the southern confines of the Coteau des Prairies, a desolate, barren, knobby country commences, where the

higher grounds are covered with gravel and erratic masses, supporting a scanty vegetation, while the valleys are either wet and marshy, or filled with numerous pools, ponds, and lakes, the borders of which are inhabited by flocks of sand-hill cranes, which fill the air with their doleful cries, and where the eye may often wander in every direction towards the horizon, without discovering even a faint outline of distant timber.

This description of country prevails for about three-quarters of a degree of latitude, and between three and four degrees of longitude, embracing the water-shed where the northern branches of the Red Cedar, and Iowa, and the eastern branches of the Des Moines, take their rise. After passing the extreme sources of the Mankato, the country again improves, both in the quality of the soil and in the distribution of timber. On fairly entering the valley of the Minnesota River, we again find a fertile, well-watered, and desirable farming country. The second terrace of land bordering the Minnesota may be especially cited for its fertility and advantageous position, elevated entirely above the highest freshets, and in proximity to a belt of forest, which crosses the Minnesota about latitude 44° 30′, and which is remarkable for its unusual body of timber, in a country otherwise but scantily supplied with wood.

Mr. Macy and Dr. Shumard report a large body of fine arable land adjacent to the St. Peter's and Mankato Rivers. A tract of the best quality of second-rate land extends for three hundred miles on these streams, with an average width of more than a mile, and elevated far above high-water mark. Its siliceo-calcareous soil contains sufficient argillaceous earth to make it retentive of moisture, and varies from one to three feet in depth, resting either on drift deposits or immediately on the rocks of the country.

The only body of timber throughout this region is the forest above-mentioned, known as the Bois Franc, about twenty miles across, extending from the St. Peter's, south to the heads of the streams flowing into the Mississippi. The rest of the country is open prairie, the streams only being skirted with wood.

The alluvial lands subject to occasional overflow vary in width from a quarter of a mile to a mile or more. These form either natural meadows, covered with a luxuriant growth of grass, or are timbered with ash, elm, sugar, and white maple.

The drift-soils west of the Mississippi, except near the northern boundary of Iowa, are much superior to the drift-soils of the interior of the Chippewa Land District, in Wisconsin, the materials that compose them being not only more comminuted, but more generally intermixed with argillaceous, saline, and calcareous ingredients, and less encumbered by erratic blocks.

The result of a series of barometrical observations, made by Mr. B. C. Macy, gives seven hundred and fifty feet for the fall of the whole length of the Chippewa River, from its source to its mouth, and consequently, the elevation above Lake

Pepin, on the Upper Mississippi, of the water-shed which gives origin both to it and the Maskeg Fork of Bad River, flowing into Lake Superior.

It will be perceived that the preceding pages form a synopsis, only, of the conclusions derived from very extensive observations of the leading features of the country explored, unencumbered with details. These details, however, furnishing as they do the data whence these conclusions have been drawn, are of paramount importance, and constitute, in fact, the body of the Report herewith submitted.

Being desirous to collect as much general scientific information as possible, without interfering with the main objects of the Survey, I instructed the members of the corps, when not otherwise engaged, to record observations, and preserve specimens in those departments of natural history in which they were most proficient. Accordingly, Dr. Parry, who has a good knowledge of Botany, has reported to me his observations made in this branch of science, on the St. Peter's River, and the country lying between the Mississippi River and Lake Superior. Here I shall merely touch upon a few of the general results, referring the Department for further information to Dr. Parry's own report.

Where there is a lithological as well as a palæontological passage from one geological formation to another, there is a simultaneous change in the botany of the country. This is especially observable in the influence of the trap ranges. The vegetation superincumbent on that formation is so marked, that it may often serve to detect it when the rocks themselves are hidden from view.

The drift-deposits of the St. Peter's support a peculiar growth, among which the following are the most striking: *Castilliga sessiliflora, Psoralea esculenta* (Pomme de prairie, or Bread root), *Oenothera surrulata, Oxytropis Lambertii, Lygodesmia juncea, Orthopogon oligostrachyum.* These contrast strongly with the plants which characterize the drift-deposits occupying the height of land between the Mississippi and Lake Superior, which are *Pinus Banksiana, Vaccinium tenellum* (whortleberry), *Gaultheria procumbens* (wintergreen), and some species of *Lycopodiums,* proving a decided difference in the two regions, both in the composition of the beds of drift and the soil derived therefrom.

On the shores of Lake Superior, Dr. Parry found a singular blending of littoral and Alpine plants, as for instance *Lathyrus maritimus* (beach pea), and *Hudsonia encoides,* common to the Atlantic sea-beach, associated with *Potentilla tridentata, Cenomyce rangiferina,* common to Alpine and Arctic regions. These are adduced to show the combined influence of soil and atmosphere on vegetation.

Dr. Parry was instructed to collect as much information as possible with regard to the economical and medicinal applications of plants, used by the Indians. Several of their most important native articles of food, as he justly remarks, are found in regions where we might least expect to find the means of subsistence; thus, the wild rice fringes the innumerable lakes and rivers of this northern Indian

country, the cranberry delights in the irreclaimable marshes and bogs, and the huckleberry flourishes in the barren ridges. Most of the common articles of diet in use among the Indians, Dr. Parry has been able to refer both to their botanical terms and Indian names.

On account of the peculiar interest attached to the cryptogamia in connexion with geology, I requested Dr. Parry to pay particular attention to that class of plants. He informs me that he has collected thirty-eight species of Ferns, and the allied orders Equisitacea and Lycopodiacea.

All doubtful specimens have been referred to Dr. Torrey, of New York, especially in the classification of grasses and sedges. The mosses collected have been submitted to Mr. Wm. S. Sullivant, of Ohio.

The Indian names of the plants have been obtained partly from Mr. Ely, of La Pointe, and partly from the Rev. R. Hopkins, of Traverse des Sioux.

Mr. Pratten, one of the assistants engaged on the St. Peter's, being conversant with the subject of ornithology, I requested him to make, in addition to his other duties, observations in that department of natural history.

On the St. Peter's and its tributaries, Mr. Pratten observed ninety-five species of birds that breed in the country. The greater part of these birds are such as have a wide geographical range; only two may be considered as peculiar to the West, viz., *Embiriza pallida*, and *Icterus xanthocephalus* (yellow-headed black-bird); the latter, I believe, has not been found east of the Mississippi River. Mr. Pratten also observed, opposite the mouth of the Mankato River, the Golden Eagle, which is rather a rare bird.

A classified list of these birds will be found in the Appendix.

GEOLOGICAL SURVEY

OF

WISCONSIN, IOWA, AND MINNESOTA.

NATURAL SECTION OF HILLS, UPPER MISSISSIPPI.

CHAPTER I.

FORMATIONS OF THE UPPER MISSISSIPPI AND ITS TRIBUTARIES, BELONGING TO THE SILURIAN PERIOD.

THE Report made by me, in the autumn of 1839, of the Geological Survey of the Mineral Point District of Wisconsin, the Dubuque District of Iowa, and a portion of Northern Illinois, contains a full description of the country bordering on the Mississippi, and lying between latitude 41° 30′, and latitude 43°; or in other words, as far north as Wisconsin and Turkey Rivers. The terminating sections of that Report along the bluffs of these two streams, are taken as a starting-point, whence to commence the present description of the geology of the Upper Mississippi, north of latitude 43°. Thus the Report in question, taken in connexion with the present Report, will comprise an account of the geological features of the State of Iowa, the western part of Wisconsin, and a large portion of Minnesota Territory.

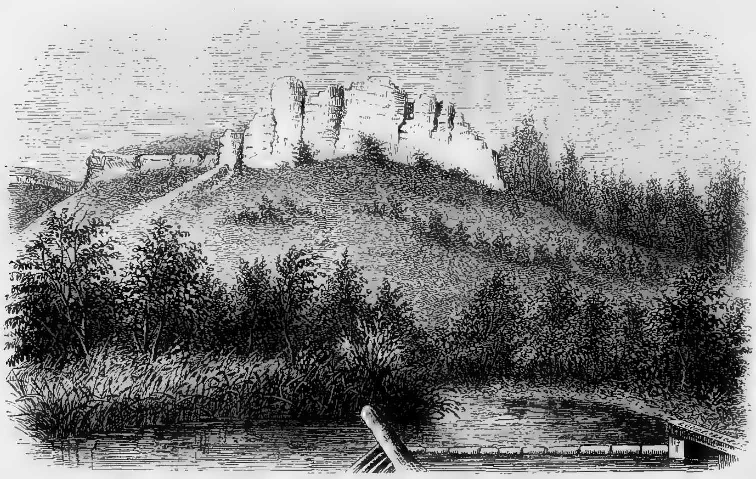
The illustration prefixed to this chapter represents a natural section, and Sect. No. 1, A, an artificial section, of the hills at Prairie du Chien; furnishing the order of superposition of the stratification, as well as the key of connexion by which to unite the survey of 1839 with those of 1847, '48, '49, and '50.

The lower terrace or projecting ledge is the upper portion of the Lower Magnesian Limestone, which forms the base of these hills, and which extends down to the level of the plain on which the village stands. It is the same rock which has been used in the construction of the church, and of several other buildings in that place. Its thickness, from the quarry at the base of the hill to the top of this projection, is about one hundred and sixty feet. The principal part of the slope between this and the second terrace, is occupied by soft sandstone, between forty and fifty feet in thickness. The second terrace marks the junction of that sandstone with the buff, blue, and gray fossiliferous limestone, which is upwards of a hundred feet thick, and fills the greater part of the upper slope, capped on the summit by the *Coscinopora* beds of the Magnesian Limestone, or Lead-bearing Rock of the Mineral Point, and Dubuque Districts of Wisconsin and Iowa.

The whole of these strata rest, as stated in my Report of 1839, on the soft, white quartzose sandstone near the level of the bed of the Mississippi.

Standing on the extensive plain on which Prairie du Chien is built, and looking up the valley of the Mississippi, one can see this range of hills stretching away for nearly four miles, and these well-defined geological terraces may be observed converging in long lines of perspective. To the eye, these benches of rock appear horizontal, but measured by the barometer, they are found gradually to rise in ascending the valley; and a still greater rise is observed in going northeast, towards the Kickapoo.

Assuming this section as a standard of comparison, the rocks constituting the base of these hills are seen to rise higher and higher going north, though the hills themselves retain nearly the same elevation; the consequence is, that, one after another, the superior strata run out and disappear; and, before proceeding many miles, the Lower Magnesian Limestone, which at first occupied their base, is found extending even to their highest summits, while the inferior Sandstone gradually



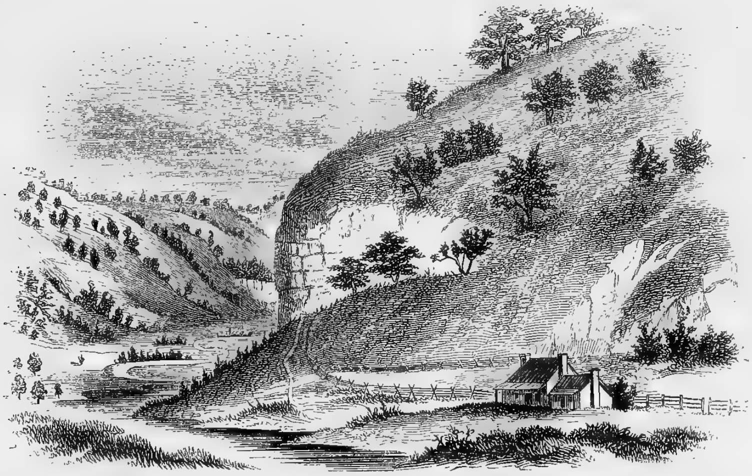
CLIFF OF LOWER MAGNESIAN LIMESTONE, PLUM CREEK.

emerges from beneath the water-courses, and at last constitutes several hundred feet of their base. Thus, at the mouth of Yellow River, this Lower Sandstone is already exposed sixty feet, and at Painted Rock, one hundred and forty-five feet; showing a rise, first of thirty feet in three miles, and then of eighty-five feet in two miles.* Again, eighteen to twenty miles northeast of Prairie du Chien, on the Kickapoo River, a tributary of the Wisconsin, and but three or four miles in a direct line from their confluence, the Lower Magnesian Limestone is already found capping the tops of the adjacent hills, as depicted above, in a sketch taken on that river, near the mouth of Plum Creek.

The cliff, on the summit, is the Lower Magnesian Limestone, and in the slope underneath are sandstones, with alternations of magnesian limestones. In consequence of the softness of the sandstones, it is often difficult to get a view of them, because they have crumbled away in the slope, and are hidden from view by vegetation. Occasionally they are more indurated, and then appear in a bold and

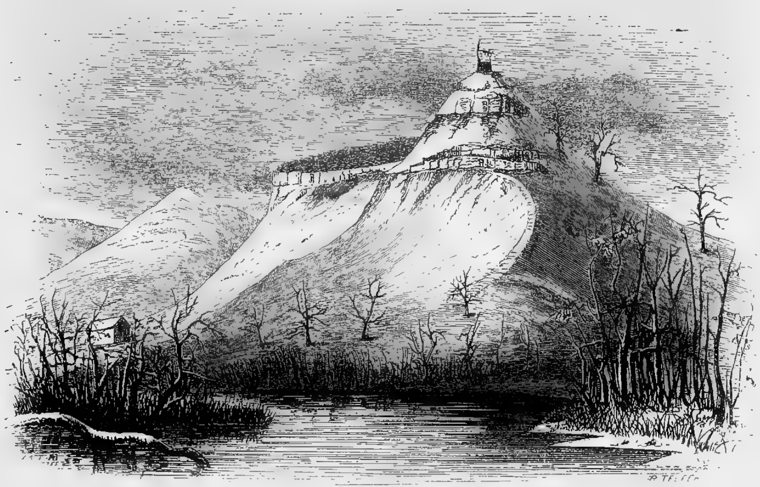
* Sect. No. 1, 2, and 3.

naked wall, as seen in the foreground of the view, taken in a cove not far from the mouth of the Kickapoo.



OUTCROP OF LOWER SANDSTONE, KICKAPOO.

Travelling still further north, or northeast, only thin beds of magnesian limestone surmount the hills, alternating with sandstone, as in Township 9 north, Range 5 west, of the 4th Principal Meridian, about ten miles above the mouth of Plum Creek, where the hills present the outline here presented.



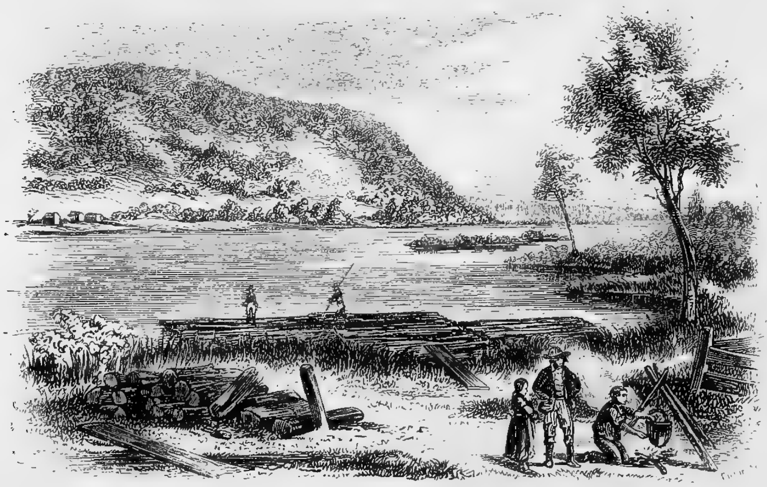
ALTERNATIONS OF MAGNESIAN LIMESTONE AND SANDSTONE, KICKAPOO.

Six or seven miles northeast of the above locality, in Township 10 north, Range 4 west, of the 4th Principal Meridian, the sandstone extends even to the tops of the hills, without any capping of magnesian limestone.

This change in the succession of the strata is caused by the northerly rise of the rocks, and their southerly dip.

But, though the general tendency of the stratification is to rise towards the north, or rather northeast, it is not uniformly so; there are, in fact, local pitches of

the strata, by which the beds that have been rising, as one ascends the streams, dip again, descending towards the river beds. While this local dip of the strata continues to prevail, the beds, which had nearly run out, again thicken, and constitute, as before, the principal part of the hills. Thus, though opposite Winnesheik's Village, and below the mouth of Bad Axe River, the Lower Magnesian Limestone capping the bluffs, is only from one hundred and thirty to one hundred and fifty feet thick, it again increases, five miles higher up, to one hundred and seventy-five feet.* Between this and Prairie à la Crosse, the northerly rise again sets in, so that at Mountain Island, the sandstone constitutes the great body of the hill, to the height of four hundred and twenty-eight feet.† About this part of the Mississippi, we have, in fact, what, in the language of the geologist, is termed the *principal axis* of the protozoic strata of the Upper Mississippi; or the *geological backbone*, whence the strata again decline, with local undulations, towards the Falls of St. Anthony.



OUTLET OF LAKE PEPIN.

Below the outlet of Lake Pepin, the Lower Sandstone constitutes about three hundred and twenty to three hundred and forty feet of the base of the hills,‡ while, above this, the Lower Magnesian Limestone rises one hundred and sixty feet. At the great bend of that lake, on the northeast side, the Lower Magnesian Limestone may be seen, forming a perpendicular wall, of nearly two hundred feet; the total height above the lake being about four hundred feet.§ This conspicuous escarpment is the spot celebrated in Indian annals as the Maiden's Rock,|| or Cap des Sioux; represented on the opposite page.

Lake Pepin is a mere expansion of the channel of the Mississippi, produced, in a great measure, by the eroding and undermining action of its waters, combined with atmospheric agencies, scooping out and carrying away the inferior soft sandstones.

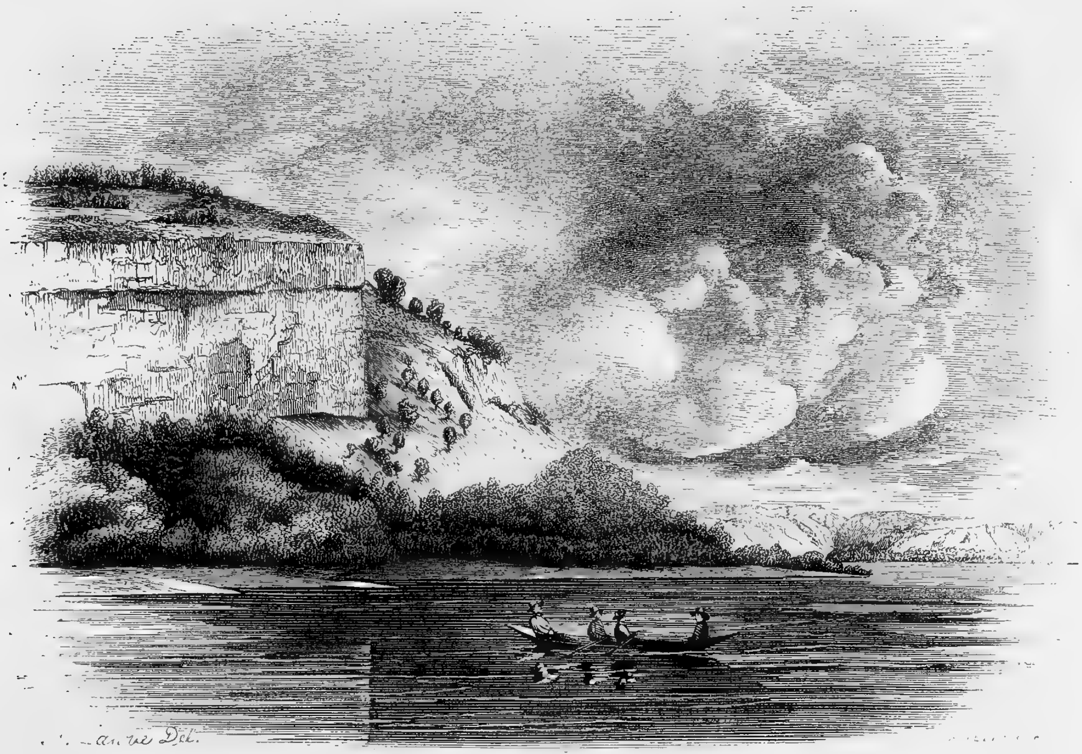
* See Sect. 1, B and C.

† See Sect. 1, No. 7, D and E.

‡ See Sect. 1, I.

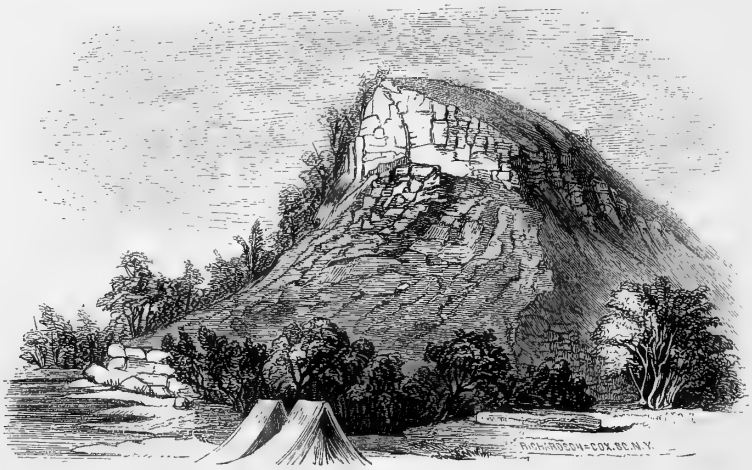
§ See Sect. 1, K.

|| The romantic legend connected with this conspicuous point, is related in Long's Expedition. It is sometimes called the Lover's Leap.



CAP DES SIOUX

A little below the Red Wing Village, near the northern extremity of Lake Pepin, is a remarkable headland, which has all the appearance of a hill split down the middle, as shown in the subjoined cut. Here the Lower Magnesian



LA GRANGE MOUNTAIN.

Limestone forms about one hundred and fifty feet of the upper portion of the hill. The base, for one hundred and eighty feet, is chiefly sandstone.*

About thirteen miles below the mouth of the St. Croix, and two or three miles below the mouth of Vermilion River, back in the bluffs west of the Mississippi, the sandstone can no longer be seen, and the Lower Magnesian Limestone extends from the water level to the height of two hundred and thirty feet.† Below the mouth of the St. Croix are low ledges only, of the same rocks, the whole height of the hill being about seventy feet, and immediately at the mouth the ledges are still lower.‡

Still ascending the stream, the strata take a local rise, so that three or four miles above the mouth of the St. Croix, the sandstone again emerges from beneath the water, and rises to the height of twelve to fifteen feet above low-water mark.§ It very soon sinks again, however, for, at Red Rock, there are only low ledges of Lower Magnesian Limestone, twelve feet thick.|| Not far beyond that locality, it disappears from the surface, so that, before reaching the town of St. Paul's, it is replaced by the Upper White Sandstone, such as has been before noticed, in the section at Prairie du Chien, as occupying the slope above the terrace of Lower Magnesian Limestone.¶

Between St. Paul's and the New Cave, going up the stream, the strata dip from twenty-five to thirty feet per mile. Thence, still ascending, there is another local rise in the strata, about ten feet to the mile.**

Connecting these and other observations, made along the Mississippi, between

* See Sect. 1, M.

† See Sect. 1, N.

‡ See Sect. 3, and background to Sect. 5; also Sect. 1, O.

§ See Sect. 1, P, and Sect. 5.

|| See Sect. 5, and Sect. 1, Q.

¶ See Sect. 1, R.

** Sect. 5, and 1 T.

the mouth of the Wisconsin River and the Falls of St. Anthony, I have constructed a series of diagrams of comparative heights, some of them above alluded to, and all to be found on Sections 1 and 5. I have also made a connected Section of the same,* in which the heights and distances are on such a scale as not to distort the geological features of the country.

For the sake of perspicuity, I have designated each formation by numbers, commencing with the lowest sandstone. The subdivisions are indicated by prefixed letters, beginning with the lowest layers. For the sake of reference, it may sometimes be convenient, in the course of this Report, to designate them by numbers and letters, in conformity with the above system of annotation.

The formations laid down in these sections extend for a considerable distance on either side of the Mississippi River, the inferior members prevailing on the east side, the superior on the west side.

The Lower Sandstone and the Lower Magnesian Limestone (F. 1 and F. 2) compose the bluffs of Hokah, of Miniskah, of Wazi Oju, and of St. Peter's River. The latter only shows itself on the Canon and Vermilion Rivers. It occupies, also, in connexion with the overlying fossiliferous limestone (F. 3), the surface of the Winnebago Reserve to near the south fork of Turkey River. Here both disappear beneath the water-courses, and are replaced by the Upper Magnesian Limestone, and that again, beyond the Wapsipinicon, by the Limestones of Red Cedar and Wapsinonox, and which form the surface rock in the Dubuque District on the lower part of those streams. Ascending the northeastern tributaries of the Mississippi, the strata rise, as has already been said (F. 2); at first forming the upper hundred or two hundred feet, but gradually running out until it is replaced by F. 1, which then occupies the entire thickness of the ridges, even to their very summits. This change takes place, on the Wisconsin River, some forty-five miles below its great bend, or a few miles east of Sauk Prairie; on Prairie à la Crosse River, about forty-five miles (by water) above its confluence with the Mississippi; on Black River, fifteen to twenty miles; on Mountain Island River, twenty to twenty-five miles; on Buffalo River, from twenty to thirty miles; on the Chippewa River, thirty-five to forty miles, or near the mouth of its east branch, the Menominie; on Rush River, about forty miles; on St. Croix River, about forty-eight miles. Allowing for inequalities in the meanders of these rivers, the approximate boundary of the Lower Magnesian Limestone will be nearly parallel with the great valley through which the Mississippi flows; and about an average distance of twenty miles from that river: as may be seen by reference to the geological chart on which the course and bearings of the formations are laid down.

The area over which F. 2 is the surface rock, is coloured on the chart of the darkest shade of purple blue; that over which F. 1 extends, chrome yellow; and this latter colour has been extended up the valleys of the streams where F. 1 forms a considerable portion of the base of the sections.

Towards the falls and rapids of these streams, the inferior members of F. 1 reach the surface in succession, and at length are found either resting immediately upon

* Sect. 2.

the granite, or separated therefrom by chloritic or ferruginous slates, or other metamorphic strata and decomposed beds.* These igneous rocks are coloured on the map with tints of red; lake representing the crystalline rocks, vermilion, red lead, and carmine the trappean. To these formations I shall revert hereafter.

FORMATION I.

LOWER SANDSTONE OF THE UPPER MISSISSIPPI.

SECTION I.

ITS LITHOLOGICAL CHARACTER.

Though light-coloured quartzose sandstone constitutes by far the largest part of F. 1, still the formation is not composed exclusively of that material. There are intercalations of magnesian limestone, especially towards its upper part, where it graduates into F. 2; and at certain localities argillaceous and other beds of a mixed character form a considerable portion of its lower mass.

In a practical point of view, this formation is one of importance, since it occupies a large area in the District. It is not less interesting in a scientific point of view. For these reasons it has received particular attention from the various corps, and its members have been studied even to the elements of stratification. Some of these deserve particular notice here. In enumerating them I shall follow the ascending order.

a. In the eastern part of the Chippewa Land District, the Assistant Geologist, Dr. J. G. Norwood, found the lowest member of this series resting on the crystalline and metamorphic rocks, a coarse sandstone overlaid by a still coarser quartzose sandstone. Dr. B. F. Shumard found an extensive quartzite formation on the Barraboo River, extending thence south to Sauk Prairie; he also observed a similar rock associated with conglomerate, bordering the confines of the granite, in the northwestern part of the District, on the St. Peter's River. In the southern part of the District, on Black River, Mr. B. C. Macy found the most inferior member a pebbly sandstone, with a coarse sandstone above it. On the east branch of the Chippewa, Professor A. Litton observed the lowest member of F. 1 to be of a similar character to that on Black River. On the main branch of the Chippewa, the lowest member of the palæozoic strata which I could find adjacent to the granite of the falls, is a coarse sandstone, with remarkable cross lines of deposition.

* At the falls of the Menominie, the intrusive rocks do not seem to have reached the surface; at least our party have not detected them. It is supposed, however, that they cannot be far beneath, for the beds which usually lie in close proximity are exposed above the waters of the stream.

b. But on the west branch of the Chippewa, or Menominie River, on the Mississippi River between Prairie à la Crosse and Lake Pepin, and especially in the northern part of the district explored, to wit, on the St. Croix, at and below its falls, the above-named varieties are not seen; at these points the lowest strata visible, and those immediately in juxtaposition with the trap of the falls, and at various points lower down, are highly fossiliferous, schistose, siliceo-calcareous layers, interlaminated with argillaceous marly beds, charged with pyrites; they are exposed some fifty feet in thickness just below the falls. A few feet above low water of the Mississippi, near the mouth of Black River and Mountain Island, there are layers of a similar description, but more intermixed with schistose sandstones and gritstones towards the upper part, occupying in all some twenty-five feet. Here, in addition to some species of the genera *Lingula* and *Orbicula*, which occur at the Falls of St. Croix, there are some remarkable forms of Trilobites, associated with numerous specimens of *Obolus*.

c. Superimposed on these is found usually a rather coarse sandstone, varying in colour from a white to brown and green, containing *Lingulas* and *Orbiculas*, and hence designated "Lingula sandstone." Its thickness at Lawrence Creek is ten or twelve to fifteen feet; but at Mountain Island and other places farther south it is much thicker.

d. This division comprises many subordinate layers; it is characterized especially by many of its beds being impregnated with green particles of silicate of iron, disseminated either through soft sandstone, incoherent sandy deposits, or in subordinate argillaceous beds, which, as at Marine Mills, are unctuous, and stain green everything with which they come in contact. It includes also three Trilobite beds, the two lower of which are gritstones: one found near the mouth of Miniskah River, the other at the top of the Marine Mill section; the third is a gray argillo-calcareous bed, found near high-water mark of Lake St. Croix, above Stillwater. It embraces also two dolomitic bands: one near its base, the other towards its top; the latter of which contains the remains of *Orthis* and *Crinoidea*. This division includes also fucoidal beds, occurring under the fourth Trilobite bed.

e. Soft, light-yellow gritstones, with hard, botryoidal, magnesio-calcareous concretions. At some localities this subdivision includes, near its base, beds of soft and fine-grained freestones, approaching in their character to tripoli.

f. Alternations of sandstone and magnesian limestone, with botryoidal layers of concretionary sandstone, and siliceous and calcareous oölite. The upper beds of this subdivision are usually nearly white, and either soft or indurated; some contain imperfect casts of Trilobites. The six principal divisions are usually persistent; some of the subordinate subdivisions are more local, or at least only obscurely marked at some localities. These latter vary too in their lithological characters, at distant points. The above arrangement is, however, their predominating character on the east side of the Mississippi, from Prairie à la Crosse to the igneous ranges on the St. Croix. Sections 1, 2, 3, and 4, give a connected view of the principal divisions. Section 6, at the Great Slide, presents most of the members, from *c* to *f*, inclusive.

SECTION II.

ITS PALÆONTOLOGY.

It had been usually believed, up to the date of my Annual Report of 1848, that the lowest members of the sandstone formation of which I am now speaking, were devoid of fossils. The geologists of our own country had set down the Lingula beds of the New York Potsdam Sandstone as the oldest fossiliferous rocks in the United States. And, in Europe, with the exception of the *Obolus Appolinis* of Eichwald, abundantly found in the inferior sandstones of the protozoic strata of Russia, no fossils whatever (according to any established system) had been described or discovered beneath what has been usually regarded as the equivalent of the above-named Lingula beds. I am now able to exhibit a new and interesting geological feature with regard to this formation.

The present Survey has brought to light the fact, that in Western America are found strata underlying coarse Lingula grits, and at a depth of seventy-five to one hundred feet beneath them, which are highly fossiliferous, and contain not the *Lingula* and *Obolus* alone, but *Orbiculas, Trilobites,* and compressed subconical bodies, resembling some forms of *Cephalopoda,* but probably not actually of that order. The sedimentary strata in which, on the Mississippi and most of its tributaries, these fossils occur, either rest immediately on the igneous rocks of Wisconsin, or are separated from them by an inconsiderable thickness of chloritic and ferruginous slates; and are, in all probability, the oldest fossil-bearing rocks yet brought to light in any part of this continent, if not of the world.*

Without assuming to determine the much-disputed question of an absolute *palæozoic base,* it may be safely asserted that the fossiliferous strata above referred to, exhibit the true base of the zoological series in the Mississippi Valley.

It was in August of 1847, while descending the St. Croix, that I first observed multitudes of *Lingulas* and *Orbiculas* disseminated in strata abutting against the protruding trap ranges which cross that stream at its falls. In tracing out the geological position of these strata, during the succeeding months of the same year, I usually found them either, as in the above instance, in almost immediate contact with the trap or granite, or else separated from these only by the lowest member of F. 1. Their depth below the base of the Lower Magnesian Limestone, I found to be not less than five hundred feet.

I observed, also, that besides *Lingulas* and *Orbiculas,* there occurred in the sand-

* In the chloritic and ferruginous slates here mentioned no organic remains have been discovered. In these rocks I am unable to trace any analogy, in lithological character, to Professor Emmons's "Taconic System." Whatever may occur elsewhere, it does not appear that in the Valley of the Upper Mississippi, any fossil-bearing rocks, deserving the name of a distinct system, occur intervening between the igneous rocks and the base of the sandstones belonging to the Silurian period.

stones of this formation (above the *Lingula* grit, however) other *Branchiopoda* and several forms of *Crinoidea*, found in peculiar green dolomitic interpolations.*

In October of the same year, while measuring sections on the Mississippi, between the Falls of St. Anthony and the mouth of the Wisconsin, I discovered within a few feet of low-water mark, ten miles below Mountain Island, on the west side of the Mississippi, laminated grits and siliceo-calcareous layers, charged with an *Obolus*, probably identical with that occurring in the inferior sandstones of Russia; and from some of the very lowest of these I collected specimens of a peculiar Trilobite, remarkable on account of the spines, with which it is provided, projecting backwards from the margin of the pygidium.†

Convinced that the formations of Iowa and Wisconsin were destined to divulge new facts relative to the palæozoic base in Western America, I caused to be instituted, during subsequent surveys in 1848, 1849, and 1850, minute stratigraphical and palæontological sections at every favourable locality. The result showed, beneath the Lower Magnesian Limestone, at least six different Trilobite beds, separated by from 10 to 150 feet of intervening strata.

I communicated this fact, in general terms, in my Preliminary Report of October 11, 1847, and more at large in my Annual Report for 1848, published in the spring of 1849.

The largest species of *Trilobite* obtained in this formation, and which I have named *Dikelocephalus*, is figured on Plate I., fig. 1. It occurs a few feet above the water level on Lake St. Croix, imbedded in a species of hydraulic limestone (the fifth Trilobite bed), near the top of member *d*, of F. 1.‡

Many of the fossiliferous beds of this formation are densely crowded with organic relics; as much so as the most fossiliferous of the blue limestones of Ohio, Indiana, and Kentucky. The proportion of genera and species, it is true, is not great, but the number of individuals is immense; some slabs are so covered with shells, that it would be difficult to place the finger on a spot without touching some of them.§

If we except the white sandstone, the uppermost bed of F. 1 *e*, that upon which the Lower Magnesian Limestone (F. 2) rests, nothing definite was known, up to the period of the present survey, of the nature or character of the underlying beds just described; neither had any well-defined organic remains been described anywhere beneath the gray and blue fossiliferous beds which form the upper

* The analysis of a coarse, buff, crystalline variety of these beds, is as follows:

Moisture,	0·40
Insoluble earthy matter,	2·74
Carbonate of lime,	48·24
Carbonate of magnesia,	42·43
Protoxide of iron, with a trace of alumina,	6·14
Loss,	0·05
	100·00

† See Tab. 1, Figs. 4 and 5, and Tab. 1, A. Figs. 11, 14, 15.

‡ For a detailed description of this and other fossils occurring in this formation, see Appendix.

§ See Tab. 1, B. Fig. 1.

portion of the sections at Prairie du Chien; so that there was an entire absence of all palæontological evidence as to the exact place which these strata occupied in the Western geological series. It is, therefore, with no small degree of satisfaction that I find myself able to disclose a new feature in the palæontology of Western America, and thus to furnish, not only to the geologist a key to the stratigraphical position of the rocks north of the Wisconsin River, but, at the same time, to the miner his surest and safest guide by which to direct operations in the search after mineral wealth.

The following table exhibits the most persistent elements of stratification of this Great Sandstone Formation; showing the relative position of the different Trilobite beds, and the thickness of the intervening strata.

TABLE OF THE ELEMENTARY STRATIFICATION OF THE LOWEST PROTOZOIC SANDSTONES. FORMATION 1.

			Feet.	Inches.
f	Sixth Trilobite bed.	Quartzose, light-coloured sandstones, of various degrees of induration, with intercalations of beds of Magnesian Limestone, with glistening crystalline facets, and calcareo-siliceous oölite, produced by rounded grains of quartz, encased in calcareous cement, containing *Euomphalus* and imperfect Trilobites. Locally, with a band of green earth,	50 to 85	
		Mammillary and botryoidal layer of white sandstone; sometimes banded with yellow,		5 to 6
e		Thick beds of soft, yellowish, and brown sandstone, sometimes with botryoidal, hard, projecting concretions, passing downwards into fine-grained, soft sandstones, approaching tripoli,	40 to 50	
d	Fifth Trilobite bed.	Ash-coloured and yellowish argillo-calcareous and magnesio-calcareous beds, containing *Dikelocephalus Minnesotensis.* Stillwater Trilobite bed,	8 to 10	
		Green, red, and yellowish sandstones, with thin, schistose, dolomitic intercalations,	40	
		Upper, brown dolomitic layers, containing *Orthis, Lingulas,* and columns of Crinoidea, as at La Grange Mountain,	4	
	Fourth Trilobite bed.	Alternations of yellow, laminated sandstones, with green particles disseminated,	5	
		Marine Mill Trilobite grit,	5	
		Fucoidal layers, and thin-bedded green and yellow sandstones; at their base; often a band of about six inches of green earth, used by the Indians as a pigment,	30 to 40	
		Green and red sandstones, charged with silicate of iron,	5	
		Loose, green sand, and soft, green sandstone,	15	
	Third Trilobite bed.	Micaceous sandstone, containing *Dikelocephalus Meniskaensis, D. granulosa,* &c.,	3	
		Alternations of green and ferruginous sandstones,	20	
		Micaceous sandstones, containing *D. Meniskaensis,* &c.,	2	
		Thin layers of green sand, alternating with green earth, impregnated with silicate of iron,	30 to 40	
		Lower, brown siliceo-calcareous and dolomitic bands of Mountain Island, and elsewhere,	4	
		Soft, thin-bedded sandstones, with scales of mica disseminated,	10 to 15	

			Feet.
c		Coarse lingula grit, green, yellow, sometimes almost white,	100 to 130
b	Second Trilobite bed.	Fine grit. Place of the Menominie Trilobite grit.(?) White and yellow sandstone, and Obolus layers of Black River, .	15
	First Trilobite bed.	Ferruginous Trilobite grits. Schistose sandstone, containing fork-tailed Trilobite beds, and Obolus layers, . . .	1 to 8
		Magnesio-calcareous rock, with Obolus and fork-tailed Trilobite,	3
		Highly fossiliferous, schistose, siliceo-calcareous layers, interlaminated with argillaceous, marly beds, charged with sulphate of iron; the former full of *Lingulas* and *Orbiculas*. (Falls of St. Croix), ...	50
a		Sandstone, with oblique lines of deposition, alternating with pebbly sandstones, and coarse grits of the Chippewa, and Black, and Wisconsin Rivers, near the Falls, . . .	50 to 100
		Place of the Lake Superior ferruginous and argillaceous sandstones, shales, and conglomerates, ...	5,000

SECTION III.

ITS MINERAL CONTENTS.

The series composing F. 1, which we have now under consideration, consists, therefore, chiefly of light-coloured, quartzose, soft sandstone, with some intercalations of argillaceous, argillo-calcareous, and earthy, deposits. Such incoherent beds are unfavourable for the retention of mineral matters, since they present to any rents, fissures, or horizontal openings which may traverse them, crumbling and unstable walls, and, consequently, do not retain that openness of fissure favourable for the reception of ores and the accompanying spars. We have seen, however, that there are intercalations of magnesian limestone interposed between these strata. These are more favourable for the retention of metallic veins; but they form, at most localities, only a subordinate part of the whole.

Judging from the experience of other mining districts, the country over which these rocks prevail is not likely to be a productive mineral region; nevertheless, between the Mississippi and Kickapoo, on the southeast quarter of Section 27, Township 10 north, Range 5 west, of the 4th Principal Meridian, where the formation in question forms the basis of the adjacent country, copper ore has been discovered; not, however, in immediate connexion with the sandstone. For the wall-rock to which the ore was traced, and which bounds it on the southeast, is a true magnesian limestone, possessing the characters usual in that formation throughout the lead and copper localities of the Mineral Point District, yet belonging to an older subdivision of the Protozoic rocks.

This Kickapoo copper ore is of rather a singular character; it is of a light green colour, with a waxy lustre and fracture, and very brittle. It is disseminated

through ferruginous earthy matter composed chiefly of the brown oxide of iron.*

It was first discovered by a Mr. Sterling, in March, 1843, on the north slope of a hill, the foot of which is watered by Copper Creek, a small tributary which runs west into the Mississippi, though the locality is only four and a half miles from the Kickapoo. It was subsequently explored to some extent by the same individual, and proved to be a bed from twelve to fifteen feet wide and five to seven deep, spreading out, as it descended the slope, to thirty feet wide, and conformable to the outline of the hill. On tracing it to the south, it was followed to near the brow of the hill, where it pitches to the southeast parallel with a wall of magnesian limestone, and almost perpendicularly. The wall of magnesian limestone is quite solid, and without apparent stratification. A shaft of fifty feet was first sunk from the surface; then a drift of ninety feet was run on the west side of the perpendicular wall of rock; and afterwards another shaft of twelve feet at the end of the drift. To the north a gallery was run forty feet, and then six feet sunk perpendicularly. The copper ore extended both horizontally and vertically as far as these excavations were carried. Below the bed of copper ore, on the slope of the hill, was a tough, greenish-gray earth, fifteen inches thick, and about the same width as the bed of ore. The whole rested on broken masses of magnesian limestone with green seams running through them.

The position of the copper ore, green earth, and fragmentary rock, indicates that it was once enclosed in a fissure of magnesian limestone. By decaying and denuding influences the walls seem to have parted, so that the northwest side fell down the slope towards Copper Creek, along with the ore and vein-stuff, which seem subsequently to have been partially removed and scattered down the declivity by the agency of rains and floods. Small pieces of rock of the appearance of trap were found mixed with the ore, but none was discovered in place anywhere in this vicinity.

The mine lies well for drainage, and the ore is of a kind easily reduced in the furnace, and yields so good a percentage of copper (about twenty per cent.) that it would be well worth the expense to prove this mine further than has yet been done. At a small cost, the value of this discovery could be determined by ascertaining to what extent the ore is likely to traverse the magnesian limestone before entering the sandstone; in which latter formation, the vein would probably dwindle or entirely disappear.

* The analysis of this copper ore, in the humid way, gave, from a gramme:—

Water,	11·2	
Carbonic acid,	05·0	
Insoluble silicates, with a trace of oxide of iron,	08·3	
Protoxide of copper,	25·0	= 19·87 per cent. of Metallic Copper.
Peroxide of iron,	48·7	
Protoxide of manganese,	00·2	
Alumina,	00·6	
Carbonate of lime,	00·8	
Loss,	00·2	
	100·0	

Mr. Sterling informed me that he had transported 24,000 pounds of the ore to Mineral Point, and had it smelted by Mr. Preston. It yielded, according to his statement, twenty-three per cent. of copper. This is only three per cent. more than the result of my analysis, made in the humid way, from a sample of ore from this Kickapoo mine, carefully averaged. The excess obtained by reducing in the furnace is probably iron and other impurities remaining with the copper.

Carson and Sterling, of Mineral Point, subsequently discovered copper of a similar quality on the same quarter section, only three hundred yards north of the ore bed just described.

On Section 1, Township 12, and Range 4, east of the 4th Principal Meridian, copper ore has been found in the vicinity of the Barraboo River, disseminated in *pockets* through brown, ferruginous beds of sandstone, occurring towards the base of F. 1. It is a green carbonate and silicate of copper, similar in character to that occurring near Mineral Point, and described in my Report of 1839.

SECTION IV.

ITS PHYSICAL AND AGRICULTURAL CHARACTER.

THE scene here depicted is a conspicuous landmark on the main branch of the Chippewa, about fifty miles above its mouth. The landscape, as a whole, is by no means deficient in rural beauty; it is not, however, a country that will bear a critical examination. Based on the softer sandstone of F. 1, the surface is strewed

AMPHITHEATRE OF SAND, CHIPPEWA RIVER.

far and wide with beds of sand, once the materials of hills, of which either no vestiges now remain, or which are gradually denuding and crumbling before the slow but sure influence of atmospheric vicissitudes. Rocks, whose particles are held together so loosely that they may be crumbled between the hands, cannot be expected to resist degrading forces that have ground to powder, corroded, and swept away hundreds of feet of solid limestone. The rounded outlines of the distant hills and scooped-out valleys bear witness to the extensive denudation of the elevated lands of this region.

The Chippewa River, in making a sudden sweep, has laid bare, on its north side, as shown on the right hand of the sketch, a bank of light-yellow sand, to the depth of about forty feet. Its appearance is that of an amphitheatre of more than a quarter of a mile in length, crowned only with shallow vegetable mould of a few inches in depth; and here and there may be seen, at intervals, for several feet down the cut, dark bands, marking as many distinct soils, which once occupied the surface, and have successively been covered by drifting sand, as it shifted and was blown about by the winds over the plain.

The analysis of the soil* of this part of the Chippewa River gives ninety-three per cent. of insoluble matter, which is chiefly a fine white sand, with only two per cent. of organic matter, less than four per cent. of soluble saline matter, consisting chiefly of oxide of iron and alumina, with only a trace of calcareous earth. A soil so unstable, so arid, and so deficient in fertilizing ingredients, cannot be very attractive to the agriculturist. Locally, however, the soil of F. 1 produces better than its appearance at first indicates, on account of an admixture of lime, derived from the intercalated calcareous beds, the overlying magnesian limestone, or from drift. A belt of country, much of the same character, extends from the Menominie or the Red Cedar branch of the Chippewa, towards Black River and Prairie à la Crosse River. The average width of the tract may be forty or fifty miles; its course for about seventy miles is nearly parallel with the Mississippi, and distant from it some twenty to thirty miles. From Prairie à la Crosse River it diverges more to the east, crossing the Wisconsin between Point Bass and the Dalles. From the Menominie, north, this character of country takes a north-northeasterly course,

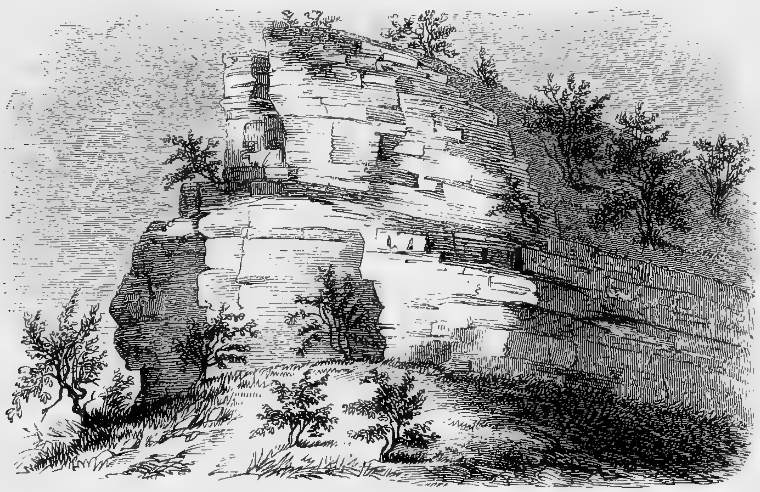
* A sandy soil, collected nine miles above the mouth of the Chippewa, in the region of F. 1, gave, from one hundred parts, as follows:—

Water,	1·02
Organic matter soluble in carbonate of ammonia,	1·75
Organic matter insoluble in carbonate of ammonia,	·25
Insoluble silicates,	93·00
Peroxide of iron,	1·65
Alumina,	1·22
Carbonate of lime,	·10
Phosphate of lime not appreciable,	·00
Carbonate of magnesia,	·01
Alkalies, not appreciable,	·00
Inorganic acids and loss,	1·00
	100·00

towards Apple River, but it appears to be less sandy in that direction, and is of a better quality, owing to admixture of more calcareous matter.

It is difficult to explain how, in certain situations, even these easily disintegrating beds of soft sandstone have partially withstood the action of forces that have swept away the surrounding material down to the level of the present prairie. Instances of this occur near Chippewa and Black Rivers, and isolated masses were seen in the vicinity of the Kickapoo, of forty to fifty feet in height; but the most remarkable examples were observed by Dr. Norwood and Dr. Shumard on the Wisconsin River, below Point Boss, and are described in their reports.*

I have already remarked that these sandstones, especially towards their upper part, are interstratified with magnesian limestone. Where this is the case, these harder beds, being undermined by the washing away of the intervening sandstones, form overhanging ledges. In such situations, rattlesnakes delight to harbour, and, in the fall of the year, in cool weather, these reptiles may frequently be seen in these warm, sandy nooks and recesses, basking in the sun. This is so common an occurrence in the bluffs on the Mississippi, below Lake Pepin, in the latter part of the month of September, that great precaution is necessary in exploring the precipitous slopes of that country.



ALTERNATIONS OF SANDSTONE AND MAGNESIAN LIMESTONE.

SECTION V.

ITS RANGE, EXTENT, AND BEARING.

The region of country over which Formation 1 is the principal surface rock, lies east of the Mississippi, and north of the Wisconsin River; bearing from southeast to northwest, parallel with that portion of the Upper Mississippi which is embraced between the mouth of the Wisconsin River and the St. Croix; forming a zone of

* See Section No. 3. S.

somewhat irregular shape, widest in its southern portion, narrowest about the centre of the belt, and averaging, throughout, about thirty-five miles in width. Beyond these confines, towards the north and east, this formation may still be seen, in isolated masses, and sometimes under fantastic forms, protruding through the drift, not only as far as the water-shed between Lake Superior and the Mississippi, and northwest towards the head waters of that stream, but, as the red sandstones of Lake Superior also belong to this formation, showing itself at the promontories of Lake Superior, and at the rapids and falls of several of the tributaries of that lake.

It will further be observed, by inspection of the Geological Chart, that an axis of elevation brings this rock to the surface over a narrow belt, crossing the Mississippi near the mouth of the Upper Iowa, and ranging thence, with a northerly curve, towards Mountain Island.

I have coloured this formation, where it shows itself as a surface rock, chrome yellow. I have also indicated, by narrow belts of the same colour, along the Mississippi, and several of its tributaries, the localities, where, though it does not form the immediate surface rock, it yet constitutes a considerable portion of the sections of bluffs exposed on either side of these streams.

SECTION VI.

ITS LOCAL DETAILS.

These will be found embodied chiefly in the appended Report of Dr. Shumard giving detailed sections on the St. Peter's, Wisconsin, Upper Mississippi, Barraboo, Snake, and Kettle Rivers; local details, regarding the lower members of the same formation, will also be found in the Reports of Dr. Norwood and Col. Whittlesey.

FORMATION II.

LOWER MAGNESIAN LIMESTONE.

SECTION I.

ITS LITHOLOGICAL CHARACTER.

The traveller who has visited the Upper Mississippi cannot fail to have remarked the peculiar outline of hill that bounds the prospect on either side of this picturesque portion of that majestic river. He must especially have noticed the conspicuous perpendicular walls of rock, that rise from out the grassy slope, or green copse wood, in massive cliffs, and terrace the heights as with interrupted natural battlements from the Makoqueta River to Lake Pepin. It is not, however, until the geology of the country has been closely inspected, that he is able to discover that the rocks composing the hills which present themselves to view below Turkey

River, do not belong to the same geological era as those which appear above the mouth of that stream. Nay, so uniform are they in their general aspect, that the miner himself, who has spent the best part of his days in excavating and exploring their recesses, is wont to regard them as identical. So they are, looking only to their chemical composition. Both are limestones, highly magnesian,* in heavy beds, of great compactness and durability; but they are separated from each other by from one hundred and fifty to two hundred feet of other strata, the upper hundred feet of which teem with peculiar races of fossil forms, constituting a distinct geological epoch, and marking a long lapse of time that has intervened between the period of deposition of these limestones. In my former report, I have designated them the "Lower" and "Upper" Magnesian Limestones of Wisconsin and Iowa. This distinction, as will appear more fully hereafter, is of the first importance in drawing conclusions regarding the mineral value of the country I have been instructed to explore.

All the conspicuous escarpments of Magnesian Limestone, south of Turkey River, are composed of the Upper of these formations, whilst all those north of Wisconsin River, as far as Lake Pepin, are of the Lower.

An inspection of hand specimens is in general not sufficient to enable even the geologist to determine from which of these Magnesian Limestone formations it has been taken, so like are the two in general aspect. Viewed on a large scale, however, some distinctive peculiarities can be observed; the Lower Magnesian Limestone has, both in its upper and lower portion, often oölitic beds† interstra-

* The proportion of lime, magnesia and insoluble silicates varies somewhat in different varieties, as may be seen by reference to the following table:

ANALYSIS OF FOUR VARIETIES OF LOWER MAGNESIAN LIMESTONE (FORMATION II.), BY J. G. NORWOOD.

LOCALITIES.	Carbonate of lime.	Carbonate of magnesia.	Earthy matter, insoluble in chlorohydric acid.	Precipitate by hydrosulphuret of ammonia in ammoniacal solution, oxide of iron, alumina, and manganese.	Water and loss.	Total.
From the shore of Lake Pepin, . . .	52	42·2	4·3	0·9	0·6	100
On Lake St. Croix, below Stillwater, .	48·3	36·8	6·9	4·3	3·7	100
Gray Cloud Island, .	51·4	40·7	A trace	4·6	3·3	100
Thirty miles below Lake Pepin, . . .	29·7	9·7	60	0·9	—	100

† This rock is composed essentially of one equivalent of carbonate of lime, and one equivalent of carbonate of magnesia; as, by the following analysis, will be apparent:

Analysis of buff oölitic bed of Magnesian Limestone, from near Cape Winnebago, intercalated in Formation 1.

Moisture, ...	0·50
Insoluble earthy matter, ...	4·84
Carbonate of lime, ...	50·93
Carbonate of magnesia, ...	41·13
Oxide of iron and alumina, ...	1·74
Loss, ...	0·86
	100·00

tified; it has occasionally green particles of silicate of the protoxide of iron* disseminated through it, and on the whole is rather more compact and darker coloured. The only certain methods, however, of determining to which of these formations any given rock belongs, is to note the order of superposition; or, still better, to determine the nature of the imbedded organic remains, which differ materially in the two.

No very important subdivisions have, as yet, been observed of the Lower Magnesian Limestone. The lower beds (F. 2 A) have locally more chert disseminated through them; there are also drusic crystals of rose-coloured quartz and calcareous spar either disseminated or in veins traversing it.

An inspection of the diagram of comparative heights and of local sections, appended to my own and to Dr. Shumard's Report, will show not only the relative thickness of the Lower Magnesian Limestone, but its elevation and depression at given distances up the valley of the Mississippi, at the more important points between Prairie du Chien and Red Rock. Where the elevation is greatest, the magnesian limestone is, as a general rule, thinnest. The variation in thickness must be regarded, however, as dependent, more upon the degree of exposure to denuding agencies, than upon any great difference in thickness of the original deposit. Where it is greatly elevated, a proportional quantity of the mass has been broken down and swept away, even down with the general level of the country.

Its greatest thickness, occurring near the mouth of the Vermilion River, and again at the mouth of Wisconsin River, is about two hundred and twenty-five feet.

SECTION II.

ITS PALÆONTOLOGY.

The Lower Magnesian Limestone of the West has been regarded as nearly, if not entirely, barren in fossils. This Survey has, however, developed some variety, among which a small species of *Lingula* and a spiral univalve are the most common. Besides these, there are other forms, allied to *Euomphalus* and *Ophileta* of Vanuxem; and Dr. Shumard found, in the same formation, in the district assigned to him for examination, on the St. Croix and St. Peter's Rivers, three species of Trilobites and a *Terebratula.*

The fossils in these rocks being, for the most part, casts, and then often very imperfect, it is difficult, and often impossible, to make out the species.

For some further particulars on this head, the reader is referred to the Appendix.

SECTION III.

ITS MINERAL CONTENTS.

In forming an opinion regarding the mineral-bearing character of a rock, in a new country, where no mines are in operation, and where little or nothing has

* When this mineral occurs, the composition of the rock is similar to that of the green crinoidal dolomitic beds, interstratified in Formation 1.

previously been done in exploring for metallic veins, the geologist has to draw his conclusions from general principles, from numerous geological observations, and from comparisons with other mineral regions; also, from precedents established by experience, and recognised by those best versed in the history and statistics of mining.

It has been shown, in my Report of 1839, that the mineral-bearing property of a geological formation depends on its lithological character, on its geological position, and on the disturbing forces which have acted on it from beneath, in lines of dislocation, especially when these are accompanied by intrusive rocks.

The Lower Magnesian Limestone, as it presents itself north of the Wisconsin River, has many characters which indicate a metalliferous rock. It occurs, as we have seen, in thick and solid walls, massive and durable; it is traversed by rents and fissures of determinate course, of which the walls have but little disposition to crumble and give way; it is intersected by spars, crystallizations, and vein stones, such as usually accompany metallic ores. Along certain parts of its range, it bears evident marks of considerable local disturbance, the signs of an adjacent axis of dislocation. It has, as already shown, many points of analogy with the Upper Magnesian Limestone of the Mineral Point and Dubuque districts of Wisconsin and Iowa,—a rock which has proved itself to be extraordinarily productive in lead ore,* and has afforded copper ore of excellent quality, which is now smelted, with

* My estimate of the annual produce in lead from the mines of the Mineral Point and Dubuque districts, for the year 1839 (Senate Doc. 407, 28th Congress, 1st Session, p. 45), was thirty millions of pounds. To the correctness of that estimate, thought by some, at the time, extravagant, subsequent shipments of lead from these mines testify.

Mr. James Carter, of Galena, has kindly furnished me with a statement of the actual recorded shipments from these mines, from February to December, in the years 1841, '42, '43, '44, '45, '46, and '47.

SHIPMENTS OF LEAD FROM GALENA AND DUBUQUE, AND ALL OTHER POINTS ON THE UPPER MISSISSIPPI, FOR THE YEARS 1841, '42, '43, '44, '45, '46, '47, '48, '49, '50, AND '51.

MONTHS.	Pigs Lead, 1841.	Pigs Lead, 1842.	Pigs Lead, 1843.	Pigs Lead, 1844.	Pigs Lead, 1845.	Pigs Lead, 1846.	Pigs Lead, 1847.	Pigs Lead, 1848.	Pigs Lead, 1849.	Pigs Lead, 1850.	Pigs Lead, 1851.
January, . . .	—	—	—	—	—	—	—	—	—	—	—
February, . . .	—	—	—	—	5,287	—	—	—	—	—	—
March, ...	4,080	80,125	—	78.636	97,746	28,841	15,669	39.170	38,615	52.311	27,379
April, ...	91,296	65,080	73,449	82.737	104,558	126.073	82.231	102.601	71,234	81,642	71,056
May, ...	91,233	46,515	122.224	89.982	93,623	142.489	119,391	109,235	84,396	86.662	71,903
June, ...	57,110	37,959	74.475	80.784	87,058	113,209	185,084	103.092	101.090	88,189	
July, ...	58,820	54,436	77.333	66,699	68,153	83,559	110,383	83,011	77.604	52.755	
August, ...	37,257	43,250	67,233	55,200	107,957	50.257	61,462	70,595	66,345	37.957	
September, . . .	16.092	39,081	45,400	54,203	63,424	58,827	67,761	63.278	46,798	55,048	
October, ...	46,286	54,941	67.473	63,072	78,887	71,668	63.825	69,168	74,207	59,740	
November, . . .	50,640	26,472	33,734	53,288	71,767	54 291	65,873	40,095	65.174	55,217	
December, . . .	—	—	—	—	—	1.500	—	—	3,471	—	
Total, ...	452,814	447,859	561,321	624,601	778.460	730,714	771,679	680,245	628,934	569,521	
First arrival of steamboats, . .	March 22	March 9	April 15	March 5	Feb. 26	March 10	March 29	March 11	March 15	March 9	March 14
Last departure of steamboats, . .	Nov. 22	Nov. 16	Nov. 26	Nov. 21	Nov. 23	Dec. 2	—	Nov. 24	Dec. 4	Nov. 28	

As a pig of lead will weigh, on an average, seventy pounds, it appears from the above table that the annual produce has varied, in the last ten years, from nearly thirty-two millions to upwards of fifty-four millions of pounds.

The decrease in the production of 1848, '49, and '50, is in part attributable to the number of volunteers in the Mexican war, and in part to emigration to the gold mines of California.

profit, in the vicinity of the mines. The Lower Magnesian Limestone may, in one respect, be considered more favourably situated than the Upper, as a mineral-bearing rock. It is an established fact in Geology, that, all other things being equal, the lower or older a rock is, the more likely it is to be metalliferous, because nearer the sources from whence experience indicates that metallic materials find their way into its recesses; in other words, because in closer proximity to rocks of igneous origin. But it has been shown that the inferior beds of the Lower Magnesian Limestone of the Upper Mississippi lie at least three or four hundred feet below the lead-bearing beds of the Upper Magnesian Limestone, and are separated from the crystalline and igneous rocks by the lower sandstones only.

By reference to my former Report in 1839 (Senate Doc. 407, p. 30), it will be seen that it was considered a remarkable circumstance that, in a mining district so rich as that south of the Wisconsin River, no basalt, greenstone, porphyry, or other intrusive or crystalline rocks, had, up to the time of the survey of 1839, been observed there, since these are in general found in place in the vicinity of productive mining districts; but I then expressed my belief, based upon the abundance of metallic lodes in that lead region, and upon irregularities in the dip of the strata in some localities, that granite and trappean rocks could not be far off. This supposition has been fully verified by the present survey. One of the most interesting of its discoveries has been the establishment of the fact that the lowest beds of F. 1, previously described, rest either immediately on crystalline or trappean rocks, or there intervenes but an inconsiderable thickness of metamorphic beds.

There can now be little doubt that the whole mining region of the Mineral Point and Dubuque districts of Wisconsin and Iowa, is based upon a syenitic and granitic platform, which would, in all probability, be reached by penetrating to the depth of from two thousand to four thousand feet.

These facts, taken together, may be considered as favourable to the metalliferous character of F. 2. Fortunately, I am able to bring several actual discoveries in corroboration of this inference.

Near the base of a bluff composed of F. 2, on the west side of the Mississippi, some ten or fifteen miles above the mouth of Turkey River, and just above the French village, from seven to ten thousand pounds of lead ore were obtained from openings in the rock by Dr. Andros. More or less galena is found here, in all the horizontal openings, for the distance of half a mile to a mile.

Near the mouth of the Kickapoo, on the southeast quarter of Section 10, Township 7 north, Range 5 west, of the 4th Principal Meridian, pieces of lead ore, weighing from half to three-quarters of a pound, have been obtained from cherty beds of the inferior part of the Lower Magnesian Limestone. A company has lately commenced exploring there, and has obtained some hundred pounds of galena.

On the opposite side of the same valley, Hearn and Ward obtained about four hundred pounds of galena; some masses weighed fifteen pounds. On Section 15, Township 7 north, Range 5 west, of the 4th Principal Meridian, some lead ore has been found.

In the hills at the first great western bend of the Kickapoo, a little below the mouth of Plum Creek, Hearn and Miller discovered some lead ore.

Half a mile south of the afore-mentioned valley, on the south half of Section 15, Township 7 north, Range 5 west, of the 4th Principal Meridian, Burns and Miller procured about one hundred pounds of lead ore.

East of the first locality, Hearn and Miller dug sixty feet, and followed an east and west lode, in which they obtained a small quantity of lead ore.

All these discoveries were made in the Lower Magnesian Limestone, F. 2.

In the same vicinity, on the south half of Sections 33, 34, and 35, Township 8 north, Range 5 west, of the 4th Principal Meridian, there are vestiges of ancient diggings wrought by the aborigines.

Between Yellow River and the Upper Iowa, Mr. A. L. Martin found several pieces of lead ore on the surface, weighing four to five ounces, and observed a place where the Indians must have excavated the hill in search of this ore.

On the Upper Iowa River, in several places east and west, crevices were observed in the Lower Magnesian Limestone, presenting symptoms of being galeniferous, especially at a bend of that river where the stream flows over solid ledges of Lower Magnesian Limestone, with bold bluffs of the same on the south side. This place is eight or ten miles below the Big Spring, and by water, about sixty miles above the confluence of the Upper Iowa with the Mississippi.

On the Wazi-oju, Mr. B. C. Macy, of the geological corps, saw a vein of lead ore of four inches in width, bearing nearly east and west, and ranging, apparently for the distance of one-half to three-quarters of a mile, through the Lower Magnesian Limestone.

To the above may be added some interesting discoveries made in this formation, between Plum and Pine Creeks, tributaries of the Kickapoo. Between these streams, in the southwest corner of Section 26, Township 8 north, Range 5 west, of the 4th Principal Meridian, on the southeast slope of a hill, copper ore, associated with hematite, was found, and traced into a crevice traversing the lower cherty beds of this formation. On the opposite side of this hill no copper has yet been noticed; but, four miles beyond, in a north-northwest direction, on the slope of another hill of about the same elevation, similar copper ore was picked up.*

About twenty miles north of the mouth of the Kickapoo, four miles west of it, and seven miles east of the copper range heretofore mentioned, in the valley of Hale's Creek, lead ore has been obtained, apparently connected with an east and west lode.

A heavy lode of lead ore is said also to have been discovered on the Half Breed tract, near the Wazi-oju, by Joseph Bison. This vein is represented as being from ten inches to a foot wide, and filled with galena embedded in the usual matrix of red, tenacious clay.

Two miles below Bad Axe River, Mr. Pratten, of the geological corps, found lead ore attached to calcareous spar, which evidently fell from the cliff of the Lower Magnesian Limestone above the spot where the specimen was picked up.

In the Winnebago Reserve, not far from the Iowa River, and a few miles northwest of the small town of Lansing, lead ore was found, in small quantities, chiefly in *pockets* and cavities.

* The samples of this ore which I analyzed yielded from 17 to 23 per cent. of copper.

The above instances abundantly prove that the Lower Magnesian Limestone, as well as the Upper, is lead-bearing; whether productively so, or not, cannot be fully determined until the rock is scientifically mined. It is certain that, at many of the above localities, the rock is exceedingly cherty, and is consequently hard, and difficult and expensive to work, and near the surface the ore is much scattered and disseminated through the rock, rather in horizontal openings than in vertical veins; still, if this surface ore should be connected with deeper-seated lodes, as there is some reason to believe it may be, then these would be well worthy the attention of the miner.

Under present circumstances, however, and with the uncertainty attaching to the last hypothesis, I have not considered it my duty to recommend lead mineral reservations where this formation prevails.

As to its copper ore, the Department will recollect that, on the 23d of November, 1848, I reported certain sections, and fractional sections, which were regarded as mineral lands, but added, that, until the chemical analyses of the various samples of ores taken from different crevices were completed, I could not decide upon their productiveness. These examinations have now been made; and their results, together with other considerations, do not, in my opinion, justify their designation as *productive* mineral lands. Some of the richest portions of the copper ore have yielded, it is true, as much as twelve per cent. of copper; and, it is possible, by the outlay of a large sum of money, veins might be followed, and finally yield a profit to the miner; but the average percentage of all the ore and copper-earth which I have analyzed will not amount to more than four or five per cent., and a great deal of it to only one per cent. In a new country, distant from a market, ores of this description are not worth working.

SECTION IV.

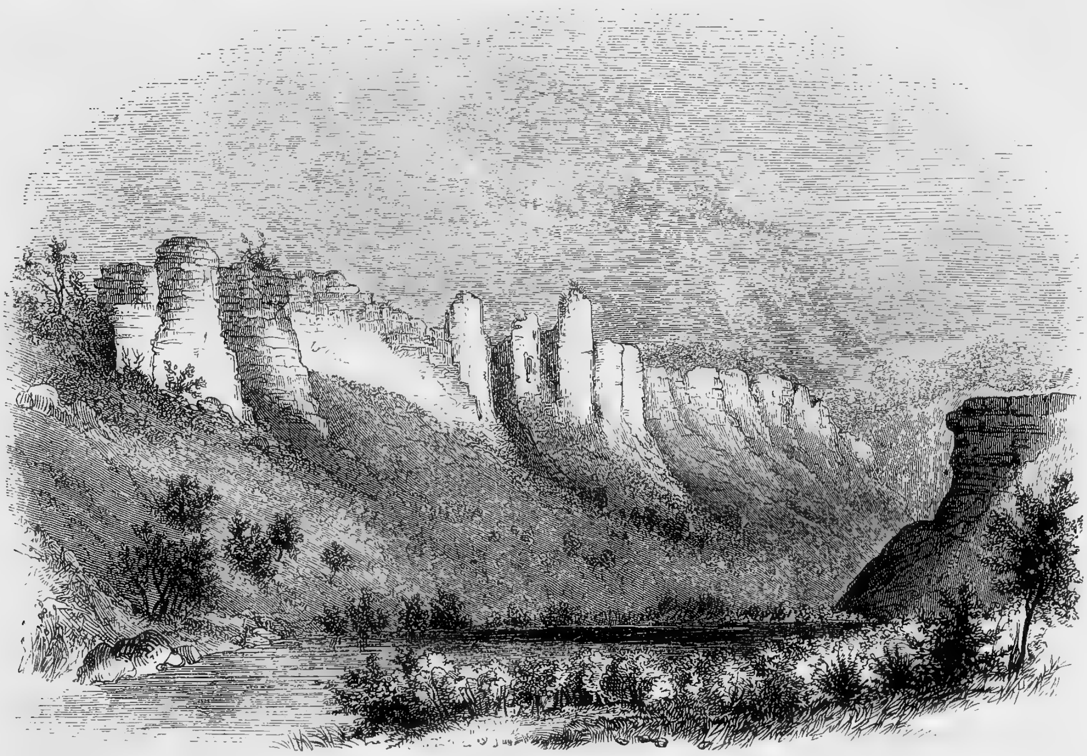
ITS PHYSICAL FEATURES AND AGRICULTURAL CHARACTER.

The constant theme of remark, whilst travelling in the region of the Upper Mississippi, occupied by the Lower Magnesian Limestone, was the picturesque character of the landscape, and, especially, the striking similarity which the rock-exposure presents to that of ruined structures.

The scenery on the Rhine, with its castellated heights, has furnished many of the most favourite subjects for the artist's pencil, and been the admiration of European travellers for centuries. Yet it is doubtful whether, in actual beauty of landscape, it is not equalled by that of some of the streams that water this region of the Far West. It is certain that, though the rock formations essentially differ, Nature has here fashioned, on an extensive scale, and in advance of all civilization, remarkable and curious counterparts to the artificial landscape which has given celebrity to that part of the European Continent.

The features of the scenery are not, indeed, of the loftiest and most impressive character,—such as one might expect to witness on approaching the source of one

of the two largest rivers on the globe. There are no elevated peaks, rising in majestic grandeur; no mountain torrents, shrouded in foam, and chafing in their rocky channels; no deep and narrow valleys, hemmed in on every side, and forming, as it were, a little world of their own; no narrow and precipitous passes, winding through circuitous defiles; no cavernous gorges, giving exit to pent-up waters; no contorted and twisted strata, affording evidence of gigantic uplift and violent throes. But the features of the scene, though less grand and bold than those of mountainous regions, are yet impressive and strongly marked. We find the luxuriant sward, clothing the hill-slope even down to the water's edge. We have the steep cliff, shooting up through it in mural escarpments. We have the

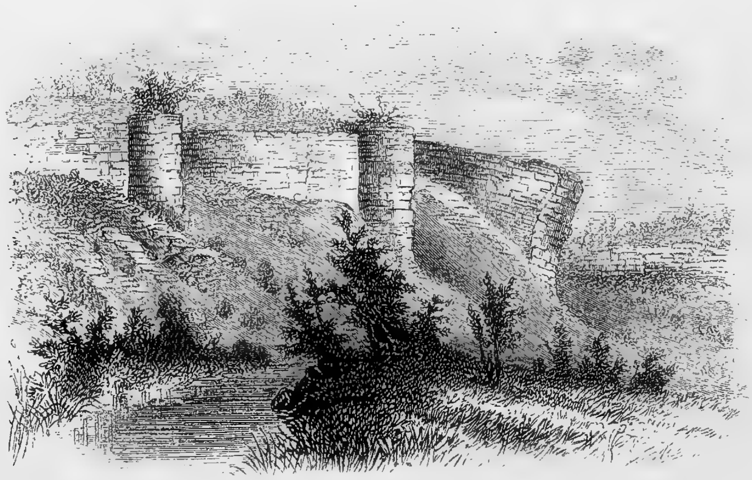


CASTELLATED APPEARANCE OF LOWER MAGNESIAN LIMESTONE, UPPER IOWA.

stream, clear as crystal, now quiet and smooth and glassy, then ruffled by a temporary rapid, or, when a terrace of rock abruptly crosses it, broken up into a small, romantic cascade. We have clumps of trees, disposed with an effect that might baffle the landscape gardener, now crowning the grassy height, now dotting the green slope with partial and isolated shade. From the hilltops, the intervening valleys wear the aspect of cultivated meadows and rich pasture-grounds, irrigated by frequent rivulets, that wend their way through fields of wild hay, fringed with flourishing willows. Here and there, occupying its nook, on the bank of the stream, at some favourable spot, occurs the solitary wigwam, with its scanty appurtenances. On the summit-levels spreads the wide prairie, decked with flowers of the gayest hue,—its long, undulating waves stretching away till sky and meadow

9

mingle in the distant horizon. The whole combination suggests the idea, not of an aboriginal wilderness, inhabited by savage tribes, but of a country lately under a high state of cultivation, and suddenly deserted by its inhabitants,—their dwellings, indeed, gone, but the castle-homes of their chieftains only partially destroyed, and showing, in ruins, on the rocky summits around. This latter feature especially aids the delusion; for the peculiar aspect of the exposed limestone, and its manner of weathering, cause it to assume a resemblance, somewhat fantastic indeed, but yet wonderfully close and faithful, to the dilapidated wall, with its crowning parapet, and its projecting buttresses, and its flanking towers, and even the lesser details that mark the fortress of the olden time. The wood-cuts towards the beginning and at the end of this section, as well as the one here inserted, represent actual exposures of the Lower Magnesian Limestone on the Upper Iowa. They will convey a better idea than any written description of the nature of the scenery on that picturesque river.

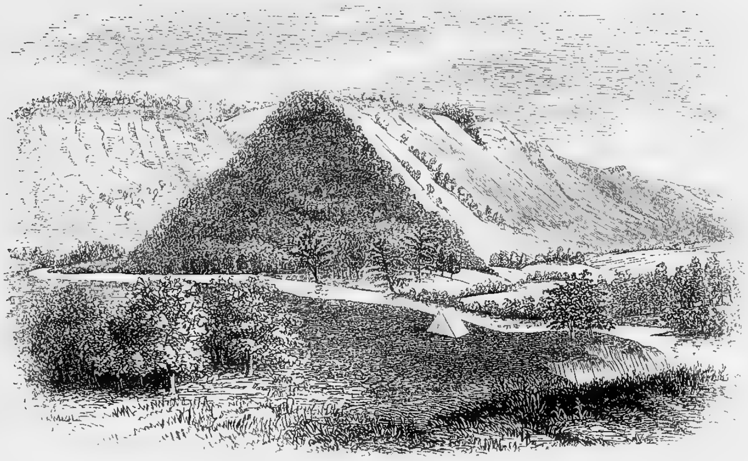


LOWER MAGNESIAN LIMESTONE, UPPER IOWA.

Bold exposures of rock, with a grassy bank beneath, such as here depicted, are, for the most part, only on the south and western sides of the hills; the northern and eastern declivities are more rounded, and, most generally, overgrown with trees and shrubbery, as illustrated by another scene on the same stream introduced on the opposite page. It seems as if the alternate thawing and freezing on the sunny side has caused a more rapid decay of the rock, which scaling and splitting off, sometimes in large masses, slips down the side of the hill; this, together with the rapid transition from heat to cold on the southern exposure, probably prevents trees from coming to maturity on that side; or, it may in part be due to some more general law, that has regulated the elevation of these Magnesian Limestones in determinate lines; thrusting the beds up to the north of the line, while a depression occurred on the south.

In some instances the hills seem as if split down the middle, one side being left standing whilst the other had been entirely carried away. La Grange Mountain, at the head of Lake Pepin, introduced on page 46, and the Cap de Killio, below the Wabasha Prairie, may be cited as examples in point.

There is a striking analogy between the physical features of the country occupied



NORTHERN AND SOUTHERN SLOPE OF HILLS.

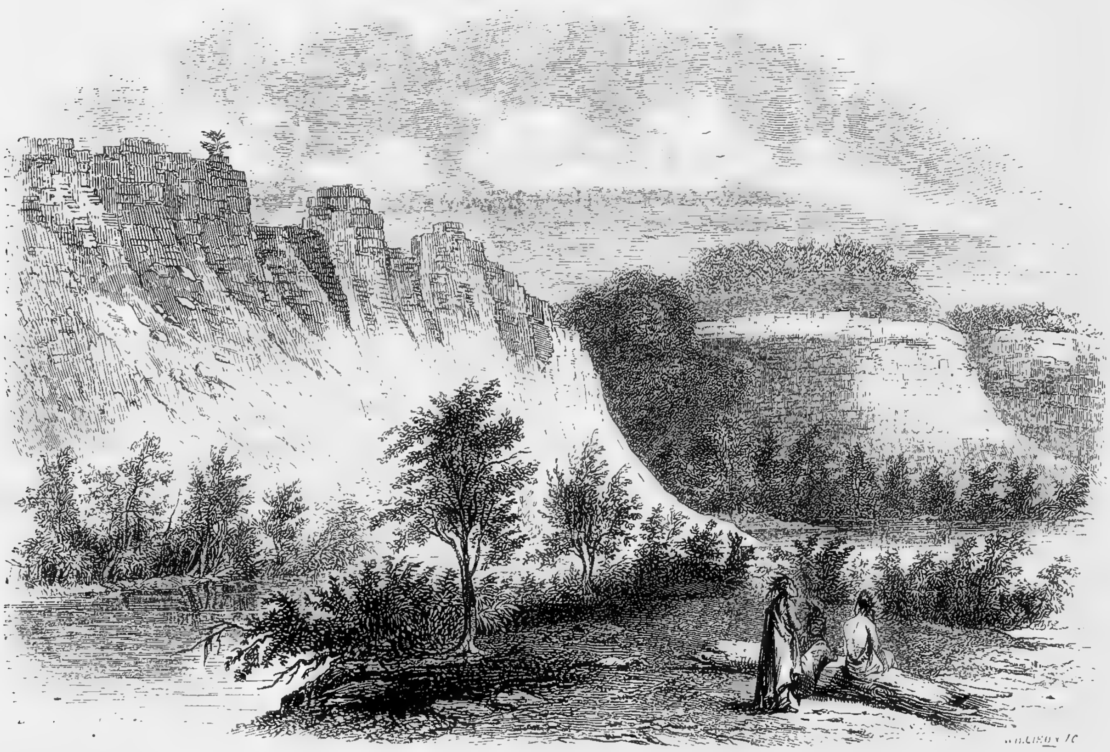
by the Lower Magnesian Limestone, and that of the district further south, in Wisconsin and Iowa, where the Upper Magnesian Limestone is the surface rock; the reason is, both rocks are so nearly alike in chemical composition, that they undergo similar changes by atmospheric agencies. There is scenery on the Upper Iowa which is almost a fac-simile of views on the Little Makoqueta River in the Dubuque District, where the rock is the Upper Magnesian Limestone. Both regions present a combination of rural beauty characteristic of a considerable portion of the Upper Mississippi. It is such as fixes itself strongly on the feelings of its inhabitants, and tends to endear to them the spot of their nativity.

The soil derived from the decomposition of the Lower Magnesian Limestone is usually of excellent quality; rich, as well in organic matter, as in those mineral salts which give rapidity to the growth of plants, and that durability which enables it to sustain a long succession of crops. The analysis of a soil,* taken from a region of this formation on the Eau Gallée, gave 8·2 per cent. of organic matter, 11·2 per cent. of salts, 77·1 per cent. of insoluble silicates, and 0·8 per cent. of carbonate of lime: this is 7·2 per cent. more salts, and 0·79 per cent. more carbonate of lime than the Chippewa soil derived from Formation 1.

* Analysis of soil taken from the region of F. 2, on the Eau Gallée.

Water,	2·50
Organic matter,	8·20
Silicic acid, dissolved by chlorohydric acid,	0·04
Carbonate of lime,	0·80
Magnesia,	0·32
Oxide of iron,	2·68
Alumina, dissolved by chlorohydric acid,	3·04
Alumina, dissolved by sulphuric acid,	1·00
Alkalies,	0·08
Phosphates of lime and iron,	0·01
Insoluble silicates,	77·10
Inorganic acids, combined with above bases, and loss,	4·23
	100·00

About the upper part of Lake Pepin, and north of it, the land lies generally level, at least sufficiently so for all agricultural purposes, except in the immediate vicinity of the streams, where the ground is often broken and abrupt. From Lake Pepin south, to the Upper Iowa, the surface is rather more broken; those portions, however, which are too uneven for other farming purposes, will afford a pastoral region of great capabilities, leaving little to be desired by the shepherd and stock farmer but a greater proportion of timber. From the base of the cliffs there often rise copious springs, cool and clear; these not unfrequently give rise to small streams, which furnish abundance of delicious trout. The rivers are well stocked with bass, carp, sunfish, pickerel, pike, and catfish. The prairies abound in game, especially deer, grouse, pheasants, and partridges; wild geese and ducks frequent the streams in immense flocks. The elevated lands would furnish high, dry pasture-ground for sheep, and the valleys and bottoms grain and hay for winter fodder.



CLIFFS OF LOWER MAGNESIAN LIMESTONE, UPPER IOWA RIVER.

SECTION V.

ITS RANGE, EXTENT AND BEARING.

THE area occupied by the Lower Magnesian Limestone lies southwest of that covered by Formation 1; forming a belt, with an average width of forty miles, and through which the Mississippi flows, nearly centrally. It is coloured on the Chart

a dark shade of purple-blue. Along the valleys of the Wisconsin, St. Peter's, and St. Croix, where the denuding action of the stream has borne away the superficial drift and more recent deposits, this limestone has also been laid bare beyond its general confines as a surface rock; indicating its extension, under the drift, in a corresponding direction, over a considerable extent of country. The narrow belts of blue along these streams indicate its actual surface exposure.

Near the mouth of St. Peter's River, before reaching the Falls of St. Anthony, this formation is lost to view under drift.

SECTION VI.

ITS LOCAL DETAILS.

These are given in the Report of Dr. Shumard, heretofore alluded to.

C. ST. PETER'S SANDSTONE.

Designated on the Sections as Formation 2 c, and superimposed on the Lower Magnesian Limestone, is another sandstone, of less thickness than that previously described. It is the rock which occupies part of the slope between the first and second terrace at Prairie du Chien, and forms the base of the bluffs at the St. Peter's. It constitutes also the lower nineteen feet of the *chute* at the Falls of St. Anthony. This sandstone, at most of the localities where it has been observed, is remarkable for its whiteness. When examined by the magnifier, it is found to be made up of grains of limpid and colourless quartz. It is even of fairer complexion than the Linn sand, used by the Scotch glass manufacturer, in the preparation of flint glass, and judging, both from its appearance and chemical composition,* I believe that this material would be equally well adapted for that purpose. It was rumoured in the north that it had been tried by some glass manufacturer, but that the result had not fully answered the expectations. If this be the case, it is probable the best quality of sand from that region could not have been selected; for the St. Peter's country certainly can afford as pure a quartzose sand as that obtained in Missouri, and now I believe extensively used in the glass-houses at Pittsburg.

The lower beds are neither as pure nor as white as the upper; at some localities this whole division of Formation 2 differs but little from the ordinary character of the purer sandstones of Formation 1. For this reason, a careful selection becomes necessary, in order to obtain the best material.

The "New Cave," mentioned by Nicollet, and well known to travellers on the

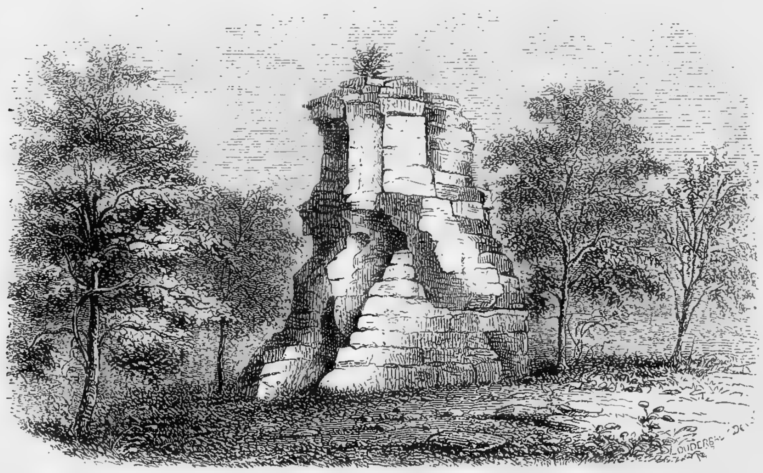
* An analysis of this rock gave but two-tenths of one per cent. of foreign matter, which is alumina, with a trace of carbonate of lime.

Six parts of the purest of this quartzose sandstone, fused in a crucible, with two parts of carbonate of potash and one part of lime, produced a glass of a similar quality and colour to that which was obtained from Linn sand treated in the same way.

Upper Mississippi, is situated in this sandstone. The effect of this cave is striking. The colourless aspect of the stone, contrasted with the deep shadows of the interior, the dark waters of a copious spring which breaks through the snow-white floor, together with the coolness of the atmosphere, call up the idea of an undermined glacier or icy arch, giving exit to some mountain torrent.

This sandstone varies in thickness from forty to one hundred feet. It appears to be destitute of organic remains; at least none have as yet come to light. In the absence of these it is difficult to say whether it ought to be considered as the terminating member of Formation 2, or the inferior member of Formation 3. Since, however, it appears to have been produced by a repetition of sedimentary action, similar to that which occurred just at the commencement of Formation 2, I have thought it best to place it, for the present, as the terminating mass of that formation.

It forms, as already remarked, part of the slope between the first and second terrace at Prairie du Chien. Beyond this locality, however, it soon runs out and is not again in place, in going north, until within a few miles of the St. Croix. Near that river, the Kinnikinick, Willow River, and Apple River, where more indurated than usual, it forms outliers, which appear in the shape of curious, symmetrical, low, flat hills, which look like artificial mounds. This wood-cut, from



OUTLIER OF SANDSTONE, KINNIKINICK.

a sketch by Mr. Lewis, represents an exposure of the upper beds composing this sandstone formation, as they appear on a hill near the Kinnikinick, examined by Dr. Shumard. He describes it as an isolated mound, surmounted by about forty feet of bare ledges of the sandstone in question, capped by a few inches of shell limestone on the summit. It is even more difficult to account for the preservation of this mass than of those formerly alluded to on the Wisconsin River, because this sandstone is, generally, of looser and more incoherent materials than the sandstone beneath Formation 2. This is the most easterly outlier of Formation 2 c, and Formation 3, on the St. Croix. Several others, with a thicker capping of limestone, are found

between two and three miles west of Lake St. Croix, one of which is represented to the left of Dr. Shumard's section, No. 1, S. Ten or twelve miles west of Lake St. Croix, this formation is in place down to the beds of the stream. (See Section 5.)

This sandstone formation appears to be destitute of other minerals foreign to its composition. Its structure is unfavourable for the retention of metallic ores, for reasons previously enlarged upon.

The narrow belt, coloured a faint yellow tint, stretching along the Wisconsin River, then crossing the Mississippi near Prairie du Chien, and bearing thence, in a northwesterly curve, towards the Upper Iowa, represents the southern exposure of this formation. The same colour, in isolated spots, ranging northeast and southwest between Yellow River and the Upper Iowa, are outliers of this sandstone. Its northern exposure, indicated by the same tint, occurs in the vicinity of St. Paul's, near the mouth of the St. Peter's, and along the Mississippi from Red Rock to the Falls of St. Anthony. It has also outliers east and west of the St. Croix.

The thickness of F. 2 C, is from forty to ninety feet, its greatest measured thickness being at Fort Snelling, near the mouth of the St. Peter's.

FORMATION III.

ST. PETER'S SHELL LIMESTONE.

SECTION I.

ITS LITHOLOGICAL CHARACTER.

Though of no great thickness, this is not the least important or the least interesting of the formations of the Upper Mississippi.

It consists of limestones disposed in thin, regular layers. These admit of three distinct subdivisions.

The lowest of these is the purest limestone of this region of country, containing nearly 65 per cent. of carbonate of lime, and 13 per cent. of carbonate of magnesia, and will, without doubt, afford, by burning, better lime than any of the calcareous rocks which we have yet examined north of Lake Pepin. It contains about 13·5 per cent. more lime, and nearly 27 per cent. less magnesia, than the Gray Cloud Island rock,—a bed in F. 2,—and twenty-two parts more lime, and fifteen parts less magnesia, than the shell limestone (the third subdivision), which forms about eleven feet of the upper portion of this formation.

The middle member of F. 3 A, is more argillaceous than either of the others, and has much the appearance of some hydraulic limestones. The experiments to which it has been subjected, on a small scale, in the laboratory, show, however,

that it does not harden very promptly under water. It contains more insoluble matter than the best hydraulic limestones.*

By consulting Dr. Shumard's section (Sec. 3, S), the relative thickness of these divisions can be seen as they are superimposed on the White Sandstone of F. 2 c.

Section 5 shows the relative elevation of these fossiliferous limestones above the Mississippi, between Red Rock and the Falls of St. Anthony.

Between New Cave and St. Peter's, on the Mississippi, in consequence of the disintegrating character of the underlying sandstone, the shell limestone has been undermined, and, from unequal support, long cleavage-lines have ensued, and the strata have sunk in places, giving the appearance of sudden local dips and disturbances. In the same vicinity, gravel and boulders may be seen, insinuated beneath the overhanging ledges of shell limestone, so as to make it appear, at first sight, as if a drift deposit had taken place after the deposition of the sandstone (F. 2 c), and before the formation of shell limestone. This phenomenon may, in part, be owing to disturbing forces acting from beneath; since, just at this place, there are sudden elevations and depressions of the strata in short distances, even to the extent of nearly a hundred feet in half a mile. (See Section 5.)

A more satisfactory explanation of it, however, is to be found in the fact of the disintegrating character of the underlying formations, which, partly by atmospheric agencies, partly by the action of the river, have crumbled and been swept away, leaving cavernous spaces underneath. Into these, gravel and boulders have been swept by the floods, or, more probably, conveyed in cakes of ice, charged with them, which, during the season of high water, and perhaps at a time when the waters flowed at a higher level than they now reach, may have been jammed beneath the ledges, and there remained, entangled in the disintegrating rubbish, until, thawing, they released their rocky burdens where now they lie.

Thus, how deceptive soever to a superficial observer the appearance of these accidental interpolations may be, it is altogether improbable that any drift-formation actually supervened between the two formations in question.

The same formation which constitutes the bluffs at the mouth of the St. Peter's, i. e., the White Sandstone (F. 2 c), and Shell Limestone (F. 3 A), extends up that stream at least half a mile, where Dr. Shumard found them in place in the bluffs. Beyond that, the strata are concealed from view by drift. The outline of the hills, however, is such as induced him to believe that the same beds form their nucleus for some miles further, before the lower rocks again reach the surface.

At the Little Rapids, about forty miles up, they are no longer in place. The

* An analysis of an earthy limestone between the Upper and Shell Limestone of St. Peter's, by Dr. Norwood, gave:

Water,	18
Insoluble silicates,	29
Carbonate of lime,	36·4
Carbonate of magnesia,	0·4
Alumina, oxide of iron, and a trace of manganese,	12·4
Loss,	3·8
	100·0

bed of the St. Peter's is there formed by ledges of soft brown sandstone (F. 1, *f*); and from this up to White Rock, eighty miles up the river, sandstones of F. 1, and magnesian limestone (F. 2), alone compose the bluffs,—the latter usually of buff and salmon colours, containing casts of *Euomphalus*, besides a few other Lower Silurian fossils, which will be found in the list in the Appendix. This is the "fawn-coloured carboniferous limestone" of Mr. Featherstonhaugh.

SECTION II.

ITS PALÆONTOLOGY.

The St. Peter's Limestone is rich in organic remains. The most commonly occurring species will be seen by consulting the tables, the Appendix, and details of this Report.

Many species, found both by Dr. Shumard and myself, in the lower shell limestone of the Upper Mississippi, are identical with forms occurring both in the substratum of gray limestone at Eagle Point, in the Dubuque District—figured and described in my Report of 1839—and in the blue limestone of the Ohio Valley. Those of the upper division resemble rather the species found in the inferior beds of the Upper Magnesian Limestone of that District. But all, so far as our examinations have yet extended, are of a Lower Silurian type.

SECTION III.

ITS MINERAL CONTENTS.

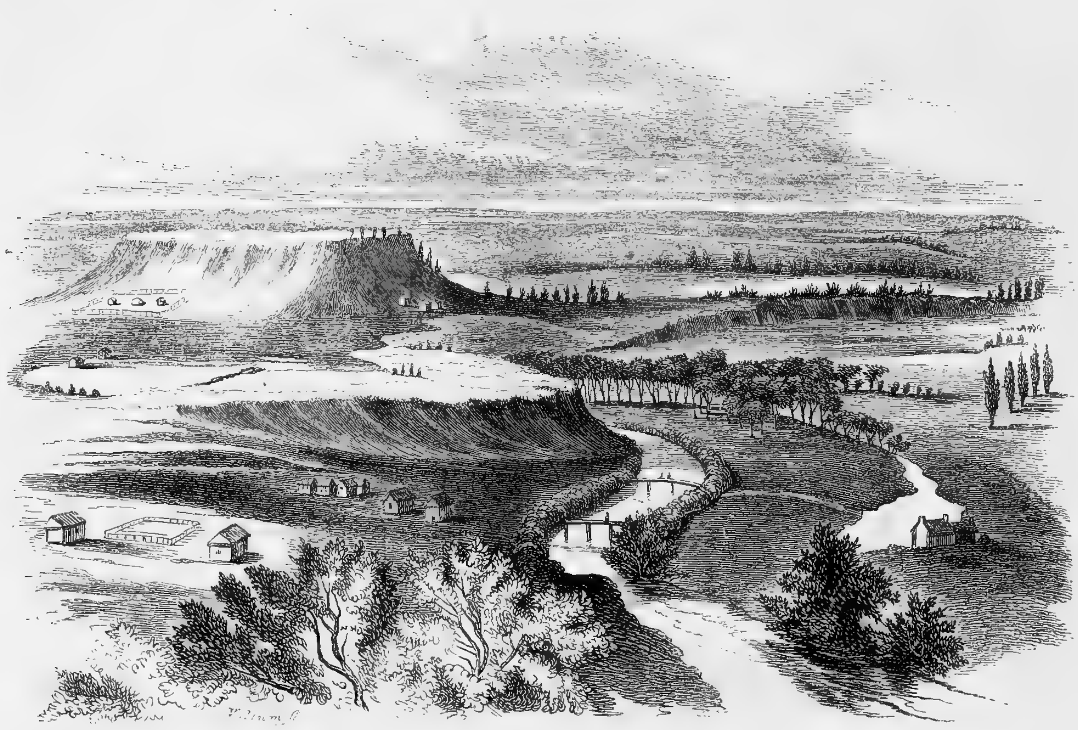
Some specimens of copper ore are reported to have been found in the vicinity of the Falls of St. Anthony. If they have, it is not likely that they originated in veins traversing this limestone formation, since neither it nor the underlying sandstone bear marks of being metalliferous. Probably they were erratic pieces transported from some copper locality lying to the north. The thickness, too, of these calcareous beds is so inconsiderable, that even if they did contain metallic lodes, these could not extend to any great depth, before they would dwindle in the incoherent sandstones beneath. But the schistose structure of the rock itself is altogether unfavourable to its metalliferous character.

SECTION IV.

ITS PHYSICAL AND AGRICULTURAL CHARACTER.

High up on Turkey River, near the site of Fort Atkinson and the location of the Winnebago Agency, this formation appears in the form of wonderfully symmetrical, mound-like forms, with flat tops, as exhibited by the following illustration.

The shell-beds, with some alternations of marly clays, form the base of these singularly shaped hills, capped with harder, more magnesian, and less fossiliferous layers.



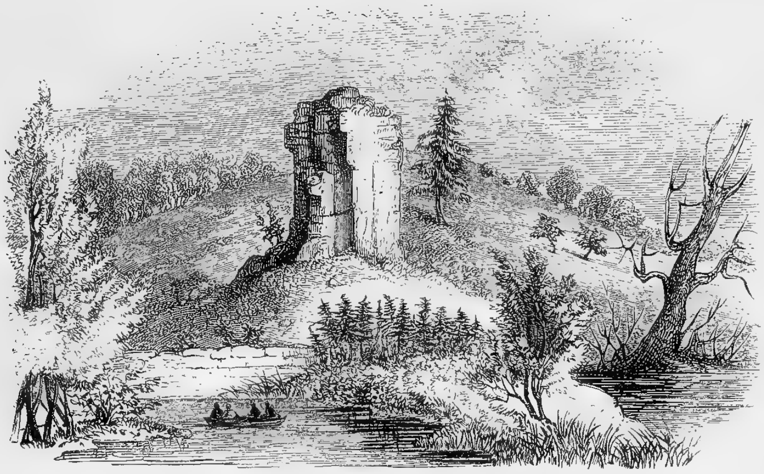
SYMMETRICAL FORM OF HILLS, TURKEY RIVER.

Below the principal forks of Turkey River, the fossiliferous strata appear only in low mural exposures, a few feet above the river, while the higher magnesian beds protrude from out the grassy slopes above in a variety of curious and fantastic shapes, and often in the buttress-like form represented on the opposite page.

The heights of Fort Snelling command an extensive prospect, both up the valley of the St. Peter's River, over the surrounding country towards the Falls of St. Anthony, and on the opposite side of the Mississippi. In all directions, as far as the eye can reach, a vast stretch of gently undulating prairie is in view, supporting a calcareous soil, which for upland is of excellent quality, and remarkable for the heavy crops of oats which it produces. While the greater portion of this soil is based on lower ledges of the limestone formation under consideration, with more or less thickness of drift intervening, other limited tracts rest upon a white shell marl and other infusorial earth, possessing fertilizing properties.

Timber is scarce on this part of the Upper Mississippi, being limited chiefly to narrow belts along the water-courses; the country adjacent to the Mississippi could, however, easily be supplied with wood, procured higher up on this river; or, if inhabited by a provident people, plantations would soon spread over the face of the country.

The Falls of St. Anthony are at present seven miles from the mouth of St. Peter's River. It is, however, more than probable, that they once occupied a position at or near Fort Snelling. Of course, little evidence can be gathered of the rate of wearing, from actual observation of the inhabitants recently settled there, but, judging from the condition of the strata themselves, there must have been a rapid retrocession. The cement which holds together the particles of the St. Peter's sandstone is so slight, that it is with difficulty a solid specimen can be obtained. Yet this is the rock, with a covering only of fifteen or twenty feet of schistose limestone, to protect it from the swift current of the Mississippi, which forms the base of the Falls.



OUTCROP OF UPPER MAGNESIAN LIMESTONE AND SHELL-BEDS, TURKEY RIVER.

The confused heaps of disjointed masses of limestone, piled together below the Falls, indicate the undermining action in progress. The inclined position, too, of the ledges of limestone there, for several hundred yards above the chute, contrary to the local dip, has mostly been produced by the water which sweeps over them entering the extensive rents which run across the strata at this place, and gradually washing out the particles of sand upon which these ledges repose, thus allowing them gradually to sink, and causing huge blocks to become, from time to time, detached and precipitated into the rapids beneath. In this way the fall will, probably, after a lapse of time, be converted into a rapid. For, in proportion as the fall shall recede, the sandstone, by reason of its dip, will diminish in thickness in the gorge, and at length disappear beneath the river bed. From observations of the dip at the Falls, this latter contingency will occur when the fall has been worn back some six or seven miles from its present position.

There can be little doubt that the rate of erosion at the Falls of St. Anthony must be more rapid than at the Falls of Niagara, since the soft sandstone of the former locality is more easily washed away than the Niagara shale.

On the brink of the gorge, near Fort Snelling, no fluviatile remains have been yet found at a height where the waters may be supposed to have flowed in former

times; but Dr. Shumard, who was instructed to collect evidence of any ancient river deposits at a higher level, observed, over the limestone at the Falls, a bed of drift of about eleven feet in thickness, and, resting thereon, a bed of sand containing *Cyclas*, *Limnea*, *Physa*, and *Planorbis*, and this deposit he traced on to the same level for nearly half a mile below the present position of the Falls.

The same gentleman also observed, half a mile below the Falls, and about a quarter of a mile east of the gorge, on rising ground, over which runs the trail to St. Paul's, a white marl charged with the same genera of shells, but of different species.

The former of these deposits is doubtless of fluviatile origin, and affords evidence of the river having flowed, at one time, for a short distance, at least, above the gorge; the latter seems to be a lacustrine deposit, the bottom of some drained lake, of which there are numerous instances in the Chippewa Land District.

If we except these beds and the underlying drift, no formations of more recent date than the shell limestones of St. Peter's were observed along the Mississippi, from the Wisconsin River to the Falls of St. Anthony. This statement will apply also to the country east of the Mississippi, as far as the water-shed between that stream and Lake Superior, except along the valley of the St. Croix above the Falls.

SECTION V.

ITS RANGE, EXTENT, AND BEARING.

Of this formation, together with its associated member, F. 2 c, the southern portion is confined to a belt, narrow, but of considerable length, ranging nearly west, on both sides of the lower portion of the Wisconsin River, but chiefly south of that stream, together with a continuation of the same belt west of the Mississippi, and ranging towards and beyond the forks of Turkey River.

Its appearance, in the north, is still more limited; being restricted to a few miles in the immediate vicinity of the Falls of St. Anthony.

In the high lands lying on both sides of the Lower St. Croix, near the Kinnikinick, also between Yellow River and the Upper Iowa, this formation occurs in outliers, assuming much the same symmetrical, mound-like forms as described and represented in the preceding section.

CHAPTER II.

FORMATION OF CEDAR, AND PART OF LOWER IOWA RIVER, BELONGING TO THE DEVONIAN PERIOD.

SECTION I.

ITS LITHOLOGICAL CHARACTER.

THE rocks referable to this age, as they occur in Iowa, are mostly calcareous strata of great purity. Many of its beds are light-coloured limestones, of close texture, and flat, conchoidal fracture, approaching in structure to some of the lithographic limestones of Europe. Other beds are limestones of similar texture, but rugged and concretionary viewed in mass; and often reticulated with thin veins of chert and sulphate of lime.

Interstratified with these are beds, more schistose, of argillaceous and marly limestones.

These rocks of Iowa differ, therefore, essentially in their lithological character from the contemporaneous great sandstone deposits, which, in Scotland, flank the southern slope of the Grampians, and encompass that portion of the eastern and western coast which lies to the north of the Friths of Forth and Clyde, as well as the northern coast of Sutherland and Caithness; while in England they occupy, in Devonshire, so large an area, as to have derived their usual appellation from that county, for the name of Devonian rocks now usually displaces that, formerly employed, of Old Red Sandstone.

So far as this formation is exposed in Iowa, no true sandstones have been observed in it,* not even of a few inches in thickness; while, in Great Britain, red sandstones, highly charged with oxide of iron, make up the principal portion of the formation.

The contrast in thickness in the two formations is equally remarkable. Nowhere in Iowa have I found an exposed connected section of these limestones measuring

* The sandstones which sometimes lie in close proximity to the limestones here spoken of, appear to be of carboniferous date.

more than sixty or seventy feet; while the depth of the Old Red Sandstone of Great Britain is said, at certain localities, to equal the elevation of Mount Etna above the sea, reaching from ten to eleven thousand feet. Its average thickness, in the British Islands, is laid down, by some authors, at about half that amount.

In the northern part of Iowa these limestones are seldom seen, by reason of the extensive drift, except in the deep cuts of the streams, and then only in low mural exposures, an example of which is shown in the middle ground of this landscape, looking over the extensive prairies in the Valley of Shell Rock, one of the eastern branches of the head waters of Cedar River.

LIMESTONES OF SHELL ROCK, CEDAR VALLEY.

SECTION II.

ITS PALÆONTOLOGY.

Palæontologically, the limestones of this period, in Cedar and Iowa Valleys, may be divided into

1. Lower coralline beds;
2. Shell beds; and
3. Upper coralloid limestone.

The beds containing the greatest abundance of *Brachiopodes* being included between beds charged with fossil corals; of which coral beds the lower is so complete

a mass of agglutinated remains of *Polypifera*, that it may be almost considered a petrified coral reef; while the upper, though not presenting so great a variety of species, and at first view hardly recognisable except as a white, close-textured limestone, is shown, under the magnifier, to be made up almost entirely of a fossil coral, closely allied to the genus *Stromatopora*, the concentric growths of which are so minutely compact, as seldom to be detected by the naked eye. To this an exception must be noticed, in some of the layers immediately superimposed on the shell-beds, which are characterized by a considerable variety of *Cyathophyllidæ*.

The most commonly occurring fossil species in these three divisions are

1. In the lower beds. *Lithostrotion ananas* and *L. pentagonum*. To the embedded specimens of this beautiful, star-like polypifera is a portion of the Iowa limestone indebted for that appearance of great beauty, when highly polished, which has procured it the name of "Iowa marble." Unfortunately it is seldom found in masses sufficiently large for the usual purposes of commerce. *Favosites cronigera* and *F. Gothlandica, Stromatopora concentrica, Chatetes subfibrosa* (?).

2. Shell-beds. A large variety of *Terebratula reticularis, T. aspera, T. concentrica, T. concinna* (?), *Spirifer euruteines*,* *S. mucronatus* (?), and several new *Spirifers*,† *Orthis resupinata, Lucina proavia, Phacops macrophthalma*.

3. Upper coralline beds. *Cyathophyllum turbinatum* (?), *C. dianthus, C. ceratites*.‡

As yet, there have been discovered in Iowa no remains of those curious fossil fish, which form so singular a feature in the palæontology of the Old Red Sandstone of Scotland and Russia. The two localities in Indiana, where the *Macropetalichthys* was discovered (as heretofore stated in a communication from Dr. Norwood and myself to Silliman's Journal), viz.: one on Lewis Creek, in Jefferson County, and one at the Falls of the Ohio, in Clark County, remain, as yet, the only localities where rocks of that period, in the West, have furnished such remains.

In Iowa, the opportunities are but few for studying this formation and registering its fossils. The geologist who undertakes to investigate the vast prairie country of the Mississippi Valley must be provided with no common share of patience and perseverance. He must be content to travel for half a day together without seeing aught but a rich, black soil, covered, as far as the eye can reach, even down to the very edge of the small streams, with a thick and high growth of prairie grass, as shown in the vignette at the close of this section, with perhaps a faint outline of timber cutting the distant horizon. He must be prepared to wade swamps, to ford streams waist deep, or, in times of freshets, to plunge in and breast the current. He must not shrink beneath a broiling sun, without even a bush to cast a faint shadow over an occasional resting-place. He must think himself fortunate if he can reach, at night, a few scattered oaks to plenish his fire, and boil his camp-kettle; and he may consider it a special instance of good luck, if, in return, he can catch a glimpse of a rock exposure once or twice a day. He may travel for days together without lighting on any object more interesting than the hillock of the prairie dog, or the broad lair of the bison.

* Tab. iii. fig. 6. † T. iii.

‡ See Appendix, for further remarks on the organic remains of these limestones.

REGION OF DRIFT RESTING ON LIMESTONES OF DEVONIAN DATE.

SECTION III.

ITS MINERAL CONTENTS.

The structure and composition of the rocks which form the basis of this tract of country are not unfavourable for the retention of minerals; its physical features, however, do not indicate a mineral tract. Along the course of our route, no symptoms were observed of important axes of dislocation and disturbance. The surface is comparatively level; the ledges of rocks lie low and horizontal, without any abrupt uplifts or sudden faults, as if beyond the sphere of active action that has fissured, and filled with metallic matter, the magnesian limestones lying to the northeast, nearer to the Mississippi.

SECTION IV.

ITS RANGE, EXTENT, AND BEARINGS.

The superficial area of the formation under consideration is much less than that of any other system of sedimentary rocks of the District. It may be traced along the course of the Mississippi River, for the distance of about thirty miles, viz.: from near the head of Rock River Rapids, a few miles below Parkhurst, to the town of Wyoming. Thence the formation ranges, with a northwesterly curve, up the valley of Red Cedar River; forming a belt, averaging, at first, some twelve or fifteen miles only in width, but gradually enlarging, until, when in latitude 43°, it disappears under the drift of Northern Iowa, it attains a width of from thirty to thirty-five miles.

Over a large portion of this tract of country, and especially on the high grounds,

these limestones are concealed, wholly or partially, by extensive deposits of drift. Indeed, they appear mostly only in low ledges, near the water-courses.

East of the Mississippi, this belt was traced as far as Rock River; and it doubtless extends still farther west,* as limestones of the same geological era show themselves on the shores of Lake Michigan in the vicinity of Milwaukie.

Neither on the St. Peter's or its tributaries were any rocks discovered that could be referred to the period of either the Upper Silurian, Devonian, or Carboniferous Systems.

Three-quarters of a mile below the mouth of the Waraju River, there is a light gray limestone (containing at least ninety per cent. of carbonate of lime, and only a fractional per cent. of magnesia), which rests apparently conformably on the sandstones of Formation 1. This limestone differs in its appearance and composition from any of the beds of Formation 2, observed elsewhere in the Minnesota country, and resembles more those of the Devonian System found in the southern portion of the District; but since no fossils were detected in this calcareous formation, we are not able to furnish any conclusive evidence of its belonging to that system of rocks. This is the purest calcareous rock discovered as yet in the Chippewa Land District, north of latitude 43°, and will become an article of value to the inhabitants of that region of country, where limestones containing a large percentage of magnesia are so universal.

SECTION V.

ITS PHYSICAL AND AGRICULTURAL CHARACTER.

On leaving the northwestern margin of that portion of the Illinois coal-field, which, on the west side of the Mississippi, juts into Iowa, in the vicinity of Muscatine, a sudden change is observable, not only in the character of the soil, but also, to some extent, in the climate. The soil which overlies the sandstones of the coal-measures is of that warm, quick, siliceous, porous character, which rapidly advances vegetation, but is apt to leave it in a parched condition, during the droughts of summer or autumn; while, immediately north of the mouth of Mud Creek, the stiff, dark, calcareous soil, marking the transition to the limestones of Cedar Valley, appears. Though less forcing in its character than the other, this soil is much richer and more retentive; storing up the successive acquisitions and infiltrations from organic decomposition, until the proportions of geine, humus, and other organic principles rise from ten sometimes even to thirty per cent. For wheat and small grain generally, this soil is well adapted.

Though the valley of Cedar River cannot boast the dense forests of Indiana or

* In Missouri, this formation was traced, reappearing, for a very limited space, in the valley of the Aux Vasses, in Calloway County; skirting, for a short distance, one of the southern promontories of the Iowa and Missouri coal-field, in close proximity to the great uplift of Magnesian limestone, of Silurian date, in the same vicinity. It has, probably, a considerably greater range in this locality, than here ascertained and laid down by me.

Ohio, yet, for a provident people, it contains timber sufficient for fuel, fencing, and building purposes. And the absence of continuous forests is well repaid by the facility with which the settler in the prairie can, in a few years, reduce an extensive farm to excellent order; aided, as in these level meadow-lands he has an opportunity to be, in his sowing and harvesting operations, by labour-saving machinery.*

SECTION VI.

ITS LOCAL DETAILS.

WHILE awaiting, in the spring of 1849, the arrival of a voyageur to take the place of the man Gobert, who died of cholera, at Muscatine, on the 17th of May, I determined to employ the time in examining the principal quarries and rock-exposures in the vicinity of the Red Cedar River, chiefly with a view to ascertain whether any of the limestones which reach the surface in that section of country could be referred to the carboniferous or sub-carboniferous groups, or whether the coal-measures of Muscatine County abut immediately on the Devonian strata.

The result of this investigation is as follows:—

On leaving the Mississippi, and proceeding in a northerly course for two or three miles, there is a change in the soil after passing the principal branch of Mud Creek; and on Section 27, Township 79 north, Range 2 west, of the 5th Principal Meridian, on the east bank of Sugar Creek, ledges of rugged magnesian limestone rise twelve feet above the water-level at the foot of a dam. In this rock I found no well-defined fossils; but the imperfect *Terebratulæ* and *Pentameri*, as well as the lithological character, leave little doubt that it belongs to the Upper Silurian epoch. This inference was confirmed by observations on the opposite side of the same stream, where these magnesian beds are at an elevation of from fifteen to twenty feet, and have resting on them from fifteen to twenty feet of a white, brecciated, close-textured limestone, the extension of the beds of the Upper or Rock Island Rapids of the Mississippi River; at which locality the superior beds contain *Terebratula reticularis, T. aspera, Spirifer euruteines, Orthis resupinata,* and *Favosites spongites.*

In juxtaposition with these calcareous beds, in a hollow, not thirty paces from Sugar Creek, and at an elevation of twenty-five feet above the creek, a light, buff, banded freestone, an outlier of the coal formation, crops out. On Section 15, Township 79 north, Range 2 west, on the same creek, at Freeman's Quarry, are solid ledges of magnesian limestone, to the height of thirty feet. At this locality, no white limestone was observed overlying it; only some loose pieces of freestone are scattered on the slopes. In some of the slabs of magnesian limestone lying in the quarry are casts of *Cyathophyllæ*, a small *Terebratula*, and an *Orthis*, not sufficiently well preserved to make out the species. At Floyd's Mill, on the same creek, on Section 14, Township 80 north, Range 3 west, is a similar rock, having, however, a more earthy and arenaceous appearance, and sometimes banded. There

* Time did not permit a minute analysis of the Red Cedar soils.

the white, brecciated limestone lies about twenty feet above the water. On Red Cedar River, half a mile from Rochester, is magnesian limestone like that at Parkhurst, and a variety of freestone is again in close proximity; and half a mile west of the same place, twenty feet of buff-coloured earthy magnesian limestone* is exposed, with nests of calcareous spar and black specks disseminated, such as are found at the head of the Upper Rapids of the Mississippi.

On Rock Creek, a mile northeast of Rochester, a light-coloured magnesian limestone is in place; and the same rocks form ledges of thirty-five feet above the level of Rocky Run, on Section 27, Township 80 north, Range 3 west. At these latter localities the magnesian limestone is of a much lighter colour than is usual; it has, however, the texture and glistening aspect peculiar to the dolomitic rocks. Only obscure casts of organic remains are found in it.

In digging a well on Section 9, Township 80 north, Range 3 west, rock was struck at thirty-two feet, and the excavation continued for forty-three feet more, first through white, close-grained limestone, and then magnesian limestone. The top of the well is about seventy feet above the waters of the Cedar. A mile or a mile and a half from this place, on Rocky Run, earthy magnesian limestone with dark specks is exposed eight feet above the water. At the south end of Mason's Grove, the rock is a cellular magnesian limestone, containing *Entrochites.*

Between this place and Rocky Run, porphyritic boulders are scattered over the prairie, of a similar composition to those observed in the Winnebago Reserve, but smaller: about one-third the size.

At the crossing of Clear Creek, in the southern part of Cedar County, twenty-six feet of buff-coloured magnesian limestone, with cavities, is exposed in a quarry. The lower strata, to the height of fifteen feet, lie in heavy beds from one and a half to three feet thick; the next foot is composed of layers of from one to three inches thick, and over the whole the beds are much broken, and irregularly divided. Were it not for the cavities in the thick beds, a good building material might be obtained at this locality.

At the crossing of Breakneck Creek, on the road from Rochester to Marion, the rocks are schistose, even-bedded, and ring under the hammer, possessing a texture like some of the Davenport limestone.

On Section 11, Township 83 north, Range 7 west, of the 5th Principal Meridian, west side of Indian Creek, the upper rock is compact, close-textured limestone, resting on magnesian limestone beneath.

At the source of the Big Spring, that drives M'Leod's Mill, on Section 9, Township 83 north, Range 7 west, a partial exposure is seen of soft, yellow, magnesian limestone, like that observed at Quarry Creek, near Parkhurst.

The bed of Cedar River, at the rapids in Linn County, is formed of white and gray compact limestone, containing *Terebratula reticularis, Orthis resupinata, Spirifer euruteines, Lithostrotion hexagonum, L. ananas, Favosites Gothlandica* (var. *F. basaltica*), *Gorgonia retiformis* (?), and a small species of *Cystiphyllum.* The quarry

* This rock has the same lithological appearance as the Quarry Creek rock, which gave, by Dr. Shumard's analysis, 42·1 per cent. of carbonate of magnesia.

near by, which has been opened in the prairie bottom, is composed of thin, even-bedded limestones, containing nests of calcareous spar. It afforded, however, but few or no fossils.

On the high ground between the Rapids and Marion, on Section 15, Township 83 north, Range 7 west, of the 5th Principal Meridian, freestones like those of the coal series occur; whilst, a quarter of a mile north of this place, both buff-coloured magnesian, and white, compact limestone are in place.

In sinking wells on the prairie on which Marion stands, a schistose limestone is struck at a depth of from thirty to thirty-five feet. The soil and subsoil are usually fifteen feet deep. Beneath these, a stiff, blue clay sets in, sometimes passing into yellow clay, enclosing water-worn pebbles. Under this clay is an ancient vegetable mould, intermixed with sticks, leaves, and timber. This soil rests upon the above-mentioned limestones.

Water rises plentifully to the height of seven feet in the wells, on penetrating the ancient soil.

Small particles of lead ore are reported to have been found in digging the foundation of the court-house at Marion. It is possible, however, that it may have been pyrites, or blende, ores which are of more frequent occurrence in the formations prevalent in Linn County.

Where the Tipton Road, passing through Linn Grove, crosses Big Creek, compact magnesian limestone is overlaid by white and buff-coloured limestone. In the bed of Cedar, in Township 80 north, Range 3 west, of the 5th Principal Meridian, probably on Sections 34 and 27, limestone, possessing a close lithographic texture, is found, at a low stage of the river.

In Linn County, eight miles north of Marion, and four miles from Cedar, there is a remarkably large boulder, at least fifteen feet in diameter. A horse and wagon standing behind it are entirely hidden.

The stonecutters of Iowa City are supplied with gravestones from a quarry of cream-coloured limestone, which lies in thin, even-bedded layers, to the height of from thirty to forty feet above Cedar River, in the south part of Township 82 north, Range 5 west, of the 5th Principal Meridian. The lowest strata, which are the thickest, hardly exceed eight inches. In some of the layers, small hemispherical concretions run in the joints of the strata, as well as through the substance of the rock itself. The best of the slabs approximate in character to lithographic limestone. They are, however, of rather too coarse a texture for fine work. The upper strata are striped with yellow, obliquely to the bedding. On Section 28, Township 81 north, Range 4 west, where the south line of the section strikes the river, above Washington Ferry, the rocks are of the same character as at the last-described quarry, only in rather thicker layers of a yet coarser texture. The lowest layers have very much the aspect of the beds observed on the west side of Clear Creek. A north and south crevice traverses the rock at this place, containing some calcareous spar and ferruginous clay; but no metallic ores have been discovered, the crevice being filled with tumbled wall-rock intermixed with red clay. The strata have a southerly dip of 3°. A corresponding wall of rock is also on the opposite side of the river, which would form solid natural abutments for a bridge.

A quarter of a mile lower down, near the middle of Section 34, of the same township and range, below Washington Ferry, there is a fine quarry of heavy beds of subcrystalline magnesian limestone. This rock, which is of the Upper Silurian period, dips southwesterly under the thin-bedded limestones above the Ferry. These latter appear, from their chemical composition, to belong to the Devonian System, although no evidence was derived from organic remains, which are very scarce at both localities. Some well-known Devonian forms are, however, in the debris of the river near by.

In Hickory Grove, on the southeast corner of Section 34, Township 80 north, Range 4 west, of the 5th Principal Meridian, both magnesian limestone and white limestone lie within two yards of each other; the latter containing *Spirifer euruteines, Gorgonia retiformis* (?), and a *Stromatopora* of the same species as that found in the Winnebago Reserve.

No boulders were found near Cedar River, in townships 79, 80, and 81. A few only were noticed in the east part of Johnson County, eight miles from Iowa City, near the Dubuque Road.

The inferences to be deduced from the foregoing observations, made in Iowa on both sides of Cedar River, in Muscatine, Johnson, Cedar, and Linn Counties, are as follows:

All the rocks, as well those referable to the Upper Silurian, as to the Devonian and Carboniferous periods, have been subjected to disturbances subsequent to the carboniferous era. These disturbances have been chiefly dislocations, through which the strata have been displaced more by abrupt vertical depressions and elevations, than by prolonged, arched, and waved movements.

The subcarboniferous limestone, which forms a zone around the coal-measures, and occupies the valley of the Mississippi, between latitude 40° and 41°, is lost to view, for forty miles beyond latitude 41° 25′; reappearing, however, in Tama County. Even those local beds of limestone mentioned in my Report of 1839, containing reticulated lamelliferous corals, and *Cyathopora Iowensis*, which it was thought might be of that age, prove, on a more minute investigation, to be of a type indicative of the period of the Hamilton Group of New York.

The calcareous beds, which constitute a conspicuous feature of the Lower Coal-measures in the Des Moines Valley, are not traceable here; the base of the Carboniferous System of Muscatine County being arenaceous and argillaceous grits, characterized by different species of *Lepidodendron*, and very large globular concretions.*

The Devonian rocks consist chiefly of close-textured white or gray limestones, sometimes brecciated, or of argillaceous limestones, both varieties containing a much smaller percentage of magnesia than the adjacent dolomitic rocks of Upper Silurian date. The former are of no great thickness, probably not exceeding seventy feet.

Rocks of the Iowa River.—On Section 10, Township 79 north, Range 6 west, of the 5th Principal Meridian, on the east side of the Iowa River, on the town plot

* See sketch at Muscatine Quarry.

of Iowa City, there is a good section of light-coloured, brownish-gray limestone, mostly of compact texture, forming a mural exposure of from thirty to forty-five feet. The lower beds lie in layers of from six to fifteen inches thick; the upper beds are in rugged, concretionary masses, very imperfectly stratified, and reticulated with a network of thin, siliceous, calcareous, and gypseous seams, and much lighter-coloured than the beds below them.

These rocks, but particularly the upper beds, have an interlocking, suture-like structure of the joints. Towards the base of the exposure, from twenty to thirty feet above the Iowa River, is a bed of brownish limestone, mottled with gray, studded with fossil corals of the species *Favosites Gothlandica*,* *Favosites polymorpha* (varieties *ramosa* and *tuberosa*), *Favosites fibrosa* (?), *Stromatopora concentrica*, *S. polymorpha*, *Lithostrotion pentagonum*, *L. ananas*,† *Cyathophyllum flexuosum*, *C. turbinatum* (?), and others. This bed seems to be the representative of the upper coralline beds of the Falls of Ohio; the corresponding beds at Utica, Indiana; the coralline burrstone on the high ground between Madison and Vernon, in the same State, and the Onondaga limestone of New York. At this locality on the Iowa River, above these coralline beds, one hundred yards from the foot of the exposure, is a seam, three inches thick, of an earthy, carbonaceous substance, a kind of coal of humus, and adjoining it, a fissure or rent in the strata, running down nearly vertically, and having a southeast bearing; but no kind of metallic ore was detected among the crevice-earth. A similar substance runs between some of the strata, and in the joints of the rock. The "black stratum" included in the upper coralline beds of the Falls of Ohio, probably owes its colour to an impregnation with a substance analogous to that found on the Iowa, where it exists in a loose, earthy, friable condition, while in Kentucky it is more intimately blended with the rock.

The rocks at this section on the Iowa have a local northerly dip of from two to three feet in a hundred yards, so that in the hollow at the head of the exposure, the coralline beds are at a higher level. There they can be seen to the depth of ten feet, composed throughout of a complete agglutination of the various species of coral above-mentioned, affording evidence that the whole mass must have been an ancient coral reef, of greater thickness and extent than is usually seen displayed in the strata of the palæozoic period, when these zoophytes did not rear such stupendous structures as at the present day; perhaps owing to interruptions from change of temperature of the ocean, as well as oscillations of its bed. Five feet above the coralline bed is a shell-bed, composed almost entirely of Gasteropoda, of the genera *Euomphalus*, *Murchisonia*, and *Pleurotomaria*, but being casts‡ which do not weather out of the rocks, and which are only seen as sections on the fractured face of the bed, it is difficult to determine their specific characters. In the concretionary and brecciated calcareous portion above, no well-defined fossils were discovered.

A few rods higher up, a small ravine runs from the high ground towards the river,

* The same specimen often shows both a double and single row of pores perforating the partition wall.

† The specimens of Iowa City marble, often seen polished, are composed of this species.

‡ The shelly part is sometimes converted into sulphate of lime.

and interrupts the continuity of the strata for the distance of about fifty paces. On crossing this hollow, a soft brown sandstone, several feet thick, with vegetable impressions, is exposed, in a low arch, fifteen feet lower than the top of the limestone. This appears to be another outlier of coal sandstone, so frequently met with in this portion of the Iowa River; which, by a fault or slip of the beds, has sunk into a depression. Thirty paces beyond the sandstones, up stream, the white limestone is again in place, at nearly the same elevation as the sandstones. In the two adjacent exposures of limestone there are no intercalations of sandstone.

About two miles and a half from Iowa City, on Section 36, Township 80 north, Range 6 west, of the 5th Principal Meridian, a schistose, marly limestone, about twenty feet thick, is exposed on the east bank of Rapid Creek, opposite Falkner's Mill, surmounted by a decomposing bed, from which loose corals of the following genera and species have become detached, and lie scattered on the surface: *Lithostrotion hexagonum* (?), *L. ananas, Cyathophyllum turbinatum, C. ceratites* (?), *C. dianthus* (?), *C. vermiculare* (?), *Cystiphyllum Devoniensis, Chætetis* (species undetermined), and *Favosites polymorpha.* The beds beneath contain chiefly shells of the following species: *Terebratula reticularis, Orthis resupinata, Spirifer euruteines,* and *Terebratula concinna* (?).

On the same creek, on Section 30, Township 80 north, Range 5 west, of the 5th Principal Meridian, sandstone with vegetable impressions occurs, in a similar position with reference to the coralline limestone as near Iowa City.

On Section 4, Township 79 north, Range 6 west, of the 5th Principal Meridian, two or three feet above the level of the Iowa River, limestone is found containing coralline beds similar to those near Iowa City; the latter extending to the height of from twelve to fifteen feet.

In ascending the Iowa, the above-described limestones occur at intervals for the distance of about twenty miles, by the meanders of the river, and twelve to fourteen miles in a direct line.

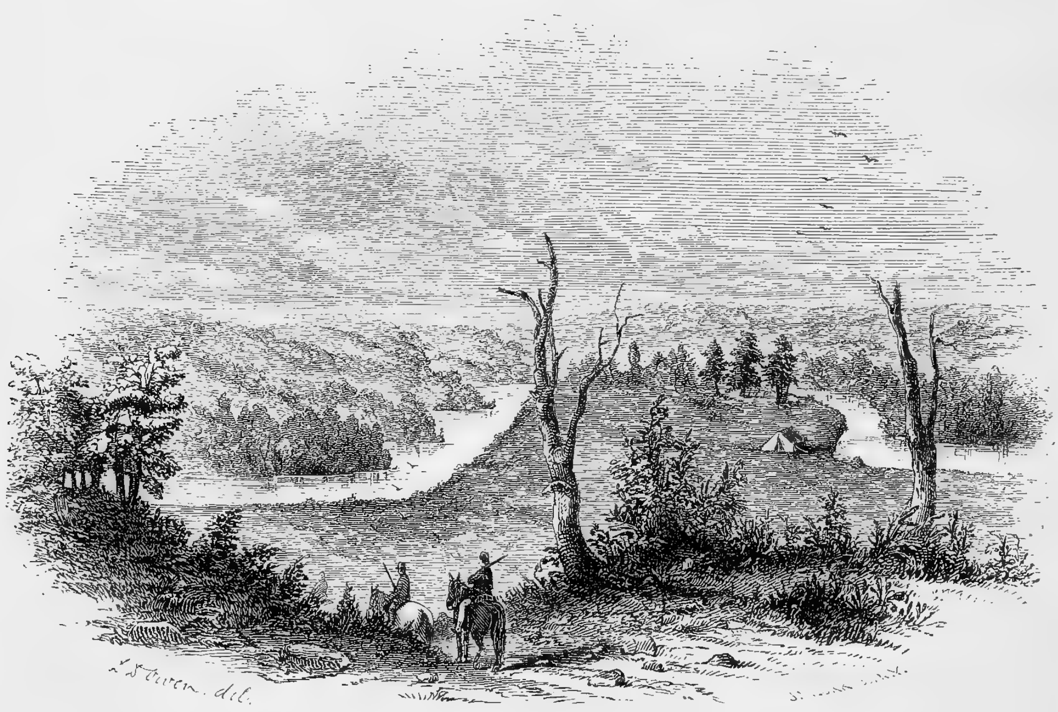
The principal exposures are as follows: Near the line between Sections 32 and 33, Township 80 north, Range 6 west, of the 5th Principal Meridian, on the west side of the river; above, and below the mouth of Newcomb's Creek, on Sections 33 and 34, same township and range, on both sides of the river, having a slight westerly dip; on Section 27, Township 80 north, Range 6 west, in a cliff of about 27 feet, on the left bank, where the strata dip 3° or 4° to the southwest. Here some of the beds are full of fossil shells, viz.: *Terebratula aspera* (very abundant), *Terebratula reticularis* (large variety), *Orthis resupinata, Spirifer euruteines; Spirifer* with a highly extended cardinal area, measuring sometimes five inches from angle to angle, which we have described in the Appendix; *Leptena* (*sp. ?*), *Phacops macrophthalma,* several reticulated lamelliferous corals, *Cyathophyllum ceratites* (?). It is at this locality that much of the rock used in the construction of the State House has been procured. The lower beds are rather schistose, but the upper are more solid and substantial, and may be obtained in blocks of from nine inches to two feet. The upper eight feet contain but few fossils.

On the opposite side of the river, on Section 22, same township and range, rocky ledges, of from thirty to forty feet in thickness, are exposed for three-quarters of a

mile, with a local northerly dip, containing *Spirifer euruteines.* On Section 15, on the left bank, there are 30 feet of regularly bedded limestone, surmounted by a bench of concretionary limestone. On Section 16, one bed is charged with *Terebratula reticularis,* and contains also *Spirifer euruteines.*

All through Townships 80 and 81 north, Range 6 west, of the 5th Principal Meridian, and as far as Section 28, Township 81 north, Range 7 west, wherever the bluffs come up to the river, ledges of limestone of the same character and age present themselves, until they finally terminate in a rugged buttress of the same concretionary and brecciated mass that forms the upper part of the section at Iowa City, the coralline beds being found a few hundred yards below, at an elevation of fifty-five feet.

After passing Section 28, Township 81 north, Range 7 west, low prairie sets in, and no rocks are visible for about twelve or fifteen miles, by the meanders of the river. On reaching a bend where the stream flows very rapidly, near where the line between Sections 28 and 29 of Townships 81 north, Range 8 west, crosses the stream from north to south, a dome-shaped mass of sandstone rests on a white sandy clay. The same kind of rock is said to be in place both on Section 27 of the same township and range, and Section 26, Township 81 north, Range 9 west, of the 5th Principal Meridian. These gritstones belong, in all probability, to the carboniferous group; but no confirmative evidence was derived from organic remains.



VIEW ON THE IOWA RIVER.

After entering Township 81 north, Range 9 west, the hills recede from the river, appearing in the distance mostly as gentle swells of from seventy to one hundred feet high, presenting beautiful sites for farms, in connexion with the rich adjacent

bottoms. The latter afford luxuriant meadows, and productive arable land when sufficiently elevated to be above overflow. On the crests of the hills are, occasionally, a few small erratics, siliceous gravel, and small angular masses of chert, but no protruding ledges in place.

It is in this vicinity, where the Iowa River meanders near the confines of the carboniferous rocks, and those particularly described in this section, that the preceding sketch was taken, from the hills on the west side of the river.

CHAPTER III.

CARBONIFEROUS ROCKS OF SOUTHERN AND WESTERN IOWA.

SECTION I.

THEIR LITHOLOGICAL CHARACTER.

THIS system of rocks admits, in Iowa, of three distinct subdivisions, namely: a great calcareous formation at the base, coal-bearing strata in the middle, and heavy beds of sandstone on the top.

Of these subdivisions, the lower consists mostly of limestones; shales and argillaceous beds predominate in the central; while gritstones almost entirely compose the upper.

With a view to determine the exact position of the workable beds of coal, of the best building materials, and of other strata of economical value, distributed through this carboniferous system, the elements of stratification of these rocks have been closely studied, and numerous sections and measurements made at many localities.

The combined Table and Section No. 1 D, to No. 40 D, minutely exhibits the most persistent lithological characters of the various beds composing the lower subdivision. The former has been constructed from more than a hundred measured sections, taken at various points on the Mississippi, Des Moines, Skunk Rivers, and their tributaries.

This subdivision consists of a lower and upper series. The former, down to within sixty feet of its base, presents an almost unbroken series of limestones, with occasional thin bands and reticulations of chert. Beneath an oölitic bed, which lies about sixty feet from the base of this formation, the limestone beds are less pure, being, to some extent, argillaceous and siliceous.

In the lower series six distinct members may be recognised. Commencing at the base we have:

1. Earthy, marly, and impure calcareous rocks; crumbling and disintegrating by atmospheric influences, so that they do not afford good building materials, and are, for the most part, concealed in the slopes by a talus of rubbish, or covered with soil and vegetation.

2. The encrinital group of Burlington, with its partings of red, ferruginous clays and marly earth, together with its substrata of oölitic and hydraulic limestones. This group terminates upwards in nearly white, semicrystalline, and semi-oölitic limestones. Several of the beds of the division afford materials for building. The oölitic bed has been much used for sills.

3. Next comes a great mass of reddish-brown limestones, alternating with numerous thin beds of chert, and many ramifications and reticulations of the same mineral. The mural escarpment below the town of Hannibal, is composed of the calcareous series comprised in this subdivision. Dimension-stones of considerable size can be obtained in these beds when sufficiently free from chert.

4. The latter division passes upwards into the gray, cherty limestones, which form the wall of rock washed by the Mississippi, below the Keokuck Landing.

5. Next come the so-called shell-beds of the Rapids of the Mississippi. They claim this appellation in a double sense,—both because they are densely crowded by fossil shells, and because many layers are schistose and "shelly" in their structure.

6. The uppermost member is appropriately termed Archimedes Limestone, inasmuch as this is the most remarkable and characteristic of its organic contents, though by no means the only fossil which it contains.

Both of these divisions afford some building material, but most of the beds are too schistose.

In the upper series, six distinct members may also be recognised:

1. At its base we have beds somewhat schistose and argillaceous, especially characterized by enclosed *Geodes*, lined with crystals of quartz and calcareous spar. These beds disintegrate by exposure, and therefore afford but indifferent building material.

2. Over these usually lie thick beds of buff magnesian limestone, either of cellular structure, or with minute tubular ramifications running through it; often with green particles disseminated. These limestones, when thick-bedded, as they often are, supply good building material.

3. This member is usually composed of sandstones, separated from the former either by thin bands of chert or by argillaceous partings, and with fine gravel disseminated. It yields tolerable building-stone.

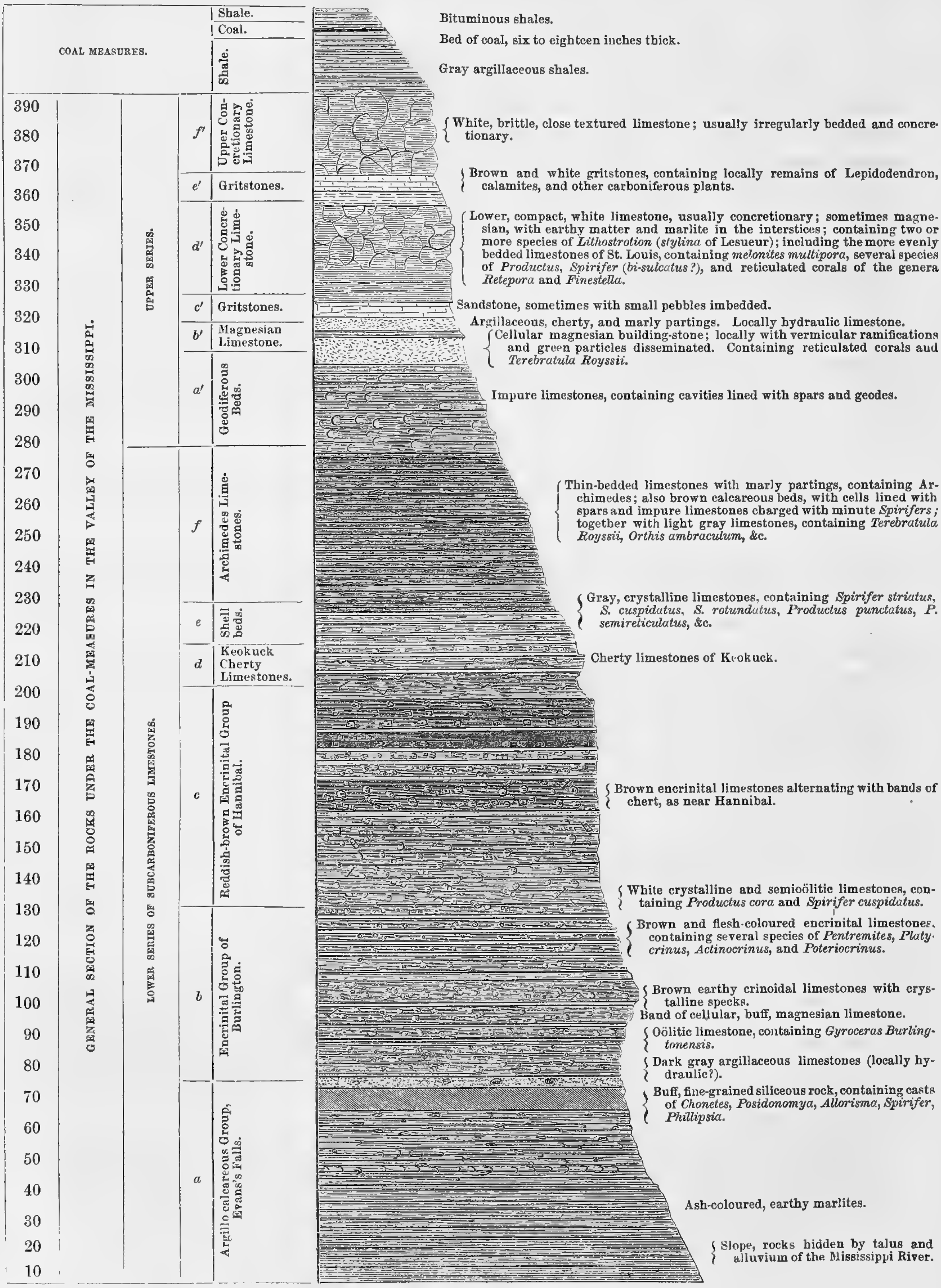
4. The lower concretionary limestone, close-grained, light-coloured; its concretions often surrounded with earthy matter and marly clay; sometimes evenly bedded, and then affording building-stones, which are seldom, however, of large dimensions.

5 and 6. Above the foregoing are again repeated gritstones and concretionary limestones. No. 6 is almost invariably concretionary in its character, with argillaceous, shaly beds of the coal-measures resting immediately upon it.

The better to enable the student of American geology to draw comparisons for the identification and parallelism of strata, I have embodied the principal facts and details in the following combined table and section, on the next page.

The approximate average thickness is given in this table, rather than the absolute thickness at any particular locality.

SECTION OF SUBCARBONIFEROUS LIMESTONES OF IOWA.



No beds of coal have been discovered interlaminated with any of these groups. The lowest bed of coal observed lies fifteen or twenty feet above the upper surface of the highest member of this series.

Subjoined is a table, contrasting the different groups that make up this series, with the beds composing the carboniferous limestone, as it occurs in Yorkshire, England, near Kettlewell and Great Whernside. Though the Yorkshire formation appears to be more than twice as thick as that of Iowa, a striking analogy may still be traced in their leading lithological features, particularly in the succession composing the upper part of the series, with its nodular and concretionary limestones at top and bottom. These speak of similar causes in operation during the period of deposition, in both formations, though they exist four thousand miles apart. It would seem that, after the deposition beneath the water of certain beds, and before complete consolidation, these were brought to the surface by slight oscillatory movements of the earth's surface; that by the action of the sun and atmosphere their surface became cracked and fissured; and when again depressed, and the interstices filled with calcareous mud and argillaceous depositions, that the whole was re-cemented.

TABLE EXHIBITING ANALOGY BETWEEN CARBONIFEROUS LIMESTONES OF YORKSHIRE AND IOWA.

LIMESTONES BETWEEN KETTLEWELL AND GREAT WHERNSIDE.	UPPER LIMESTONE SERIES, NEAR THE MOUTH OF THE DES MOINES.
(Under grits and shales.)	(Under shales.)
Limestone: a hard, sharp stone, in nodular beds.	Limestone: compact, close-textured, brittle, white; usually concretionary, with marly earth in the interstices.
Limestone: a hard, sharp stone, in nodular beds.	
Parting of shale.	
Limestone: light-coloured.	
Parting of shale.	
Limestone: light-coloured.	
Parting of shale.	
Limestone: light-coloured.	
Plate.	
Limestone: rather dark-coloured, forming bold scars.	
Parting of shale.	
Limestone.	
Fine gritstone, occasionally yielding flags.	Gritstones: brown and white.
Gray limestones, with *Producta* in the lower beds.	Limestone: compact, close-textured, brittle, white, concretionary; containing *Lithostrotion;* becoming more evenly bedded in its lower portion, and containing *Productus cora*, *P. Flemingi*, *Spirifers*, *Terebratulæ*, *Melonites*, *Multipora*, &c.
Blue limestones, very solid, full of large *Producta*, *Lithodendra*, &c.	
Red limestones, with *Encrinites* and *Spirifers*.	
Gray limestone: in bold scars.	
Black nodular limestone.	Sandstones: often with small pebbles.
Gray limestone: small-grained, compact or splintery, white or gray.	
Various limestones: mostly compact, to the level of Kettlewell-dale; including the "dun" (or magnesian) limestone, full of ramifications, nodules, or hollow cells of calcareous spar.	Magnesian limestones: buff, often cellular, or with tubular perforations.
	Limestones: impure, full of *Geodes*, containing calcareous spar and quartz.

Between the Yorkshire and American groups a further analogy is observable in the dolomitic beds. Phillips remarks:*

"The limestone in the country about Kettlewell is often liable to a local change into a crystallized yellowish or brown dolomitic rock, full of ramifications, and nodules, and hollow cells of calcareous spar. The beds and joints in this 'dun lime,' for so it is called by the workmen, are very irregular, and the rock feels heavy. Altogether, it resembles not a little the brown dolomitic rock of Gerolstein, in the Eifel. It is known to the miners that this 'dun lime' runs in lines north and south, destroying the productiveness of the veins through the whole mass of limestone."

The sections at the upper end of Wensley Dale indicate also a marked similarity in the succession of limestones and grits under the coal of Lunsthorn, to that which occurs under the lowest coal-bed on the Des Moines; though it does not appear that the Wensley Dale limestones have the peculiar nodular and concretionary character which characterize those of Kettlewell and of Iowa. The grits, too, attain a greater thickness than in Iowa, and there is more shaly matter interposed between the limestones and grits, so as to augment the transatlantic beds to nearly four times the thickness of those in Iowa.

SECTION II.

THEIR PALÆONTOLOGY.

THE study of organic remains in rocks is, indeed, a most beautiful, a most fascinating research. What can be more extraordinary: that we, the generation of the nineteenth century, should exhume from out the hard substance of the solid rocks the delicate forms of organic beings of bygone ages, and display to the wondering eye of the naturalist, even their minute, anatomical details! And this, not alone of races which inhabited this earth in times immediately preceding the human epoch; we are even permitted to contemplate, and restore to our perceptions, the very fishes, mollusks, and corals, that swarmed in the carboniferous seas millions of ages ago. The animal matter composing their tissues and bones is indeed gone, but the simultaneous mineral infiltrations preserve a perfect counterpart. We can depict those remarkable and elegant forms of vegetation which constituted the forests that fringed the shores of that same treacherous and ever-overwhelming ocean. We seize them in the very act of uncoiling their fronds, and unfold to the admiring gaze of the botanist, that luxuriant canopy of foliage that once waved in the sea-breeze nurturing their stems. We accomplish even more than this: we can read the records of myriads of the lower orders of animals, that date their existence yet further back than the times that gave growth to trees, now stored up as mineral fuel in the bowels of the earth—to times at least as long prior to the coal formation as that geological era is antecedent to the present time; we can assign to each its

* Geology of Yorkshire, p. 26.

place in the zoological systems, and fill up gaps in the existing orders of the animal and vegetable kingdoms.

To think that we, at this day, can demonstrate the structure of the eye of some of these—the most ancient races—and even count the thousand lenses by which light was concentrated to the optic nerve, is truly astonishing! Is it then surprising that it should engage the most earnest attention of the closet philosopher, and awaken the enthusiasm of the enterprising explorer?

But palæontology is not a study of mere curious, scientific inquiry; it has, also, its practical inferences, and these of the most important character, with their direct, matter-of-fact bearings. In illustration of this view of the subject, permit me, in this connexion, to direct the attention of the reader to Figs. 1, 5, and 6, of Table IV. The fossil corals represented by these engravings are found embedded in the subcarboniferous limestones, and near the top of the series; always under the true coal-bearing beds; never above these, or included in them; and nowhere else. This geological fact holds good not only in Iowa, but throughout the entire range of the subcarboniferous limestones in Indiana, Illinois, Kentucky, and Tennessee. In not a single instance, from the range of the Cumberland Mountains on the east to the interior of Iowa on the west, has a workable bed of coal been discovered in a position beneath the strata of limestone containing these corals. In these organic remains, then, we find the surest, the most unerring guide in the search after this invaluable article of commerce, that warms our houses, that drives our steam-engines, by which we navigate our rivers, lakes, and oceans; that propels the machinery, by which we weave our fabrics; that reduces our iron, by which we cultivate our soil, and carry on every conceivable mechanical operation; that refines our metals, that contributes to the production of both the necessaries and luxuries of life, and by which we transmit intelligence, with the swiftness of lightning, to stations the most remote. Without the knowledge of this fact, millions of dollars might be expended—have been expended—in fruitless and hopeless mining operations after geological incompatibilities.

All the figures on Table V., A and B, are equally persistent in their undeviating geological position, quite below the productive coal-measures, as well as beneath these same coral-bearing beds.

In stratigraphical palæontology we have, then, the safest and the most trustworthy index to direct our explorations after mineral treasures in the fossiliferous strata.

Taken as a whole, these carboniferous limestones are rich in organic relics. The lowest fossiliferous bands, under the oölitic bed, are particularly characterized by remains of bivalve Mollusca, belonging principally to the genera *Chonetes, Spirifer, Posidonomya, Archa,* and *Allorisma.* In consequence of these being chiefly casts, it is rarely possible satisfactorily to determine the species. Associated with these is occasionally found a *Phillipsia.*

The oölitic bed contains *Productus cora, Spirifer striatus,* and a gigantic species of *Gyroceras,* to which (from the locality where found) the name *Burlingtonensis,* has been given.*

* See Table V., Fig. 10.

Superimposed upon this oölitic bed are more than a hundred feet of crinoidal limestones, containing a great variety of beautiful species, belonging chiefly to the genera *Pentremites*, *Platycrinus*, *Cyathocrinus*, *Actinocrinus*, and *Poteriocrinus*, many of which are figured on Table V., A and B.

For variety and elegance of form, the species afforded by the Burlington beds of this subdivision, are probably unrivalled. In the Hannibal beds, they are neither so perfect nor so numerous. Interposed between the crinoïdal beds of these two localities, are white, semicrystalline, and semioölitic beds, in which the genera *Productus* and *Spirifer* are, also, abundant.

Above these encrinital beds occur the shell-beds, so designated, because especially rich in remains of Brachiopoda, particularly of the genera *Productus* and *Spirifer*. These beds afford, however, a considerable variety of other fossils, *Capulus*, *Cardium*, *Phillipsia*, and the teeth of certain fishes, belonging to the genus *Psammodus*, the remains of which contrast beautifully, in their rich, brown colour, with the cold, light-gray of the embedding limestone.

The thin-bedded limestones, which, in the ascending order, succeed these, contain a considerable variety, both of *Brachiopods* and *Encrinites;* but their distinguishing characteristic is the presence of those screw-shaped, reticulated corals, known as *Archimedes* (Table IV., Fig. 1). This fossil has, in these beds, a vertical range of about fifty feet, reaching to the top of the lower series.

The geodiferous group, at the base of the upper series, contains few, if any, organic remains. In the magnesian beds above are found lamelliferous, reticulated corals, referable to the genera *Fenestella*, *Gorgonia*, *Retepora*, and *Cellepora*. Also a *Chætetis*, *Terebratula lamellosa*, and a few other fossils.

In the gritstones comprising the third group, no fossils have been detected.

The fourth group, or Lower Concretionary Limestone, is chiefly characterized by a species of *Lithostrotion*, described by Lesueur under the name of *Stylina*,* from the styloid process which forms the axis of its terminating cells, and usually projects conspicuously above their general surface; especially when the fossil is of a cherty nature, as it usually is when occurring in this geological position.

This fossil coral, it would seem, is as abundant in Iowa as is the *Lithodendron* (*Diphyphyllum* of Lons.) in the vicinity of Kettlewell; and occupies the same geological position. It is also worthy of remark, that though these two corals have been referred to distinct genera, both have a prominent central axis, and otherwise so closely approximate to each other in external structure, that they are not easily distinguishable apart.

The white and brown gritstones of the fifth group occasionally contain impressions of *Calamites*, *Lepidodendrons*, and other plants of the coal-measures.

The sixth and uppermost group of the carboniferous limestone is, for the most part, destitute of fossils. Locally, a few small Terebratulæ and Spirifers have been noticed.

* Table IV., Figs. 5 and 6.

SECTION III.

THEIR MINERAL CONTENTS.

The lithological character of the lower series of subcarboniferous limestones is not unfavourable to the retention of the metalliferous exhalations and segregations; these limestones being chiefly in continuous beds, of considerable thickness. And, accordingly, beyond the range of the Geological Chart which accompanies this Report, to wit, where this formation, in its southern range, encircles the southern boundary of the Illinois coal-field, we find it affording some variety of minerals.

In Iowa, however, no metallic veins, promising to be productive, have been discovered traversing this formation.

If, in this connexion, we contrast the state of things in the two districts, we find, in Iowa, an absence of those conditions which, in Illinois, are accompanied with mineral insinuations.

Thus, the fluate of lime, traversing, in heavy veins, this formation in Southern Illinois, and there forming the veinstone or gangue of the galena, does not show itself in Iowa. Nor, though in this latter district abrupt faults frequently destroy the continuity of the strata, do these usually extend further than from fifty to a hundred feet; whereas, in Southern Illinois, disturbances are not infrequent that reach, in vertical dislocation, as many fathoms.

My judgment is, then, that the Carboniferous Limestone of Iowa contains few mineral veins; no productive ones.

In the way of building material, however, as of mineral manure, this series will furnish to the future inhabitants much that is valuable. The best locations are indicated in the detailed description of the local geological sections of this formation.

As to the middle or shaly division of this formation, already stated to be its coal-bearing portion, the exact thickness, any more than the precise character of its coal-beds, cannot be determined. In a country so recently settled, artificial sections of strata are confined to a few quarries, opened on the immediate line of the public works, and one or two shallow excavations for coal, on the Lower Des Moines. Even the natural sections are often encumbered by slides of the clayey banks, or by the detritus derived from the crumbling faces of easily-disintegrating shaly beds. And thus the attempt to obtain accurate measurements of the succession and thickness of strata is often frustrated. All the information at present accessible is comprehended in the descriptive details hereinafter given.

The workable seams of coal yet discovered in this formation do not exceed four or five in number. Nor, as our measurements indicate, is it likely that the number will be much increased, even when the coal-field comes to be fully known; since, in the British coal-fields, in the same depth of strata (less than a hundred feet), a much greater number of seams than the above is rarely found.*

* Of seams over one foot in thickness, there occur, in St. Anthony's Colliery, only *six*, in a depth of

Of this formation it is the middle or coal-bearing portion which furnishes also iron-stones, hydraulic limestones, selenite, and beds of gypsum.

Through the Des Moines country, between latitude 41° and latitude 42° 30′, crystals of selenite are very generally disseminated, in connexion with impure limestone and septaria. The heavy beds of gypsum, however, seem to be local in their distribution. Our present discoveries of this valuable mineral are confined to an area of a few miles on the Upper Des Moines, just below the Second Correction Line, and about six miles below the confluence of that river with its Lizard Fork. At that locality the supply may be considered as almost inexhaustible. Its average thickness, over an area of two miles square, may be put at twenty feet. This would give 2,787,840,000 of cubic feet. Or, as the specific gravity of this plaster stone is about 2·2 (giving 137·5 pounds as the weight of a cubic foot of gypsum), upwards of a hundred and ninety millions of tons.

No minerals of value have been discovered in the upper division of the carboniferous limestones of Iowa. They will yield, however, at various localities, good freestone for architectural purposes, grindstones, whetstones, and probably also furnace hearth-stones.

SECTION IV.

THEIR RANGE, EXTENT, AND BEARING.

The Carboniferous Limestone in Iowa, if we commence where it crosses the Des Moines, between the mouth of that river and the Missouri line, ranges north as far as the confluence of the Iowa and English Rivers; then, for about forty miles, it is lost to surface view; reappearing, on the Iowa River, in Tama County, and ranging thence, in a northwesterly direction, towards the head of that stream. There, however, it is, to a considerable extent, covered up from view by the drift, showing itself, in such cases, only in the cuts of streams. From the source of the Iowa, it sweeps off, in a westerly curve, towards the Missouri; its northern boundary, on that stream, being a few miles below the mouth of the Sioux River. Thence it bears south, down the valley of the Missouri, to the State line.

This zone of limestone has an average width of twenty-five miles; it circumscribes, with a short interval, the great coal-field which occupies the whole of Southwestern Iowa, extending north to latitude 42° 30′; and separates it from the Illinois coal-field by a calcareous belt, varying in width from twenty-five to fifty miles.

Of this coal-field (in Iowa alone, not including its extension south into Missouri), the dimensions are as follows. Its average width, from east to west, is less than two hundred miles; its greatest length from north to south, about one hundred and forty miles; its contents, about 25,000 square miles. It extends, measured in a

strata of more than 800 feet; and in the Asbey Coal-field only *twenty-one*, in a depth of 1011 feet. In these latter coal-measures, in the hundred feet yielding the greatest number of seams over a foot in thickness, there are but *six*.

direct line, nearly two hundred miles, in a northwesterly direction, up the valley of the Des Moines.*

It is bounded by an irregularly undulating line, as follows: commencing where the line between Iowa and Missouri crosses the Des Moines River, near the west border of Lee County; thence, nearly north, to the northeast corner of Washington County; thence, with a northwesterly curve, to the Iowa River, which it crosses in Township 81 north, Range 8 west, of the 5th Principal Meridian, not far from the line between Johnson and Iowa Counties; thence, up the valley of the Iowa, some twenty-five miles, when it recrosses that river, near the southeast corner of Tama County; thence, curving through Tama County, and again crossing the Iowa, to near the centre of the east line of Marshall County; thence, along the water-shed of the Iowa and Cedar, recrossing the former near the northeast corner of Township 87 north, Range 30 west, of the 5th Principal Meridian; thence, with a westerly curve, up the Iowa, and continuing west of that river to the "Big Woods," where it recrosses, for a few miles, returning to the west side of that stream, and running in a nearly due west course to the Des Moines, which it crosses six miles above the Lizard Fork; thence, with a southwesterly curve, towards the head-waters of the Three Rivers; thence, down the valley of Neshnabotna, to the State line.

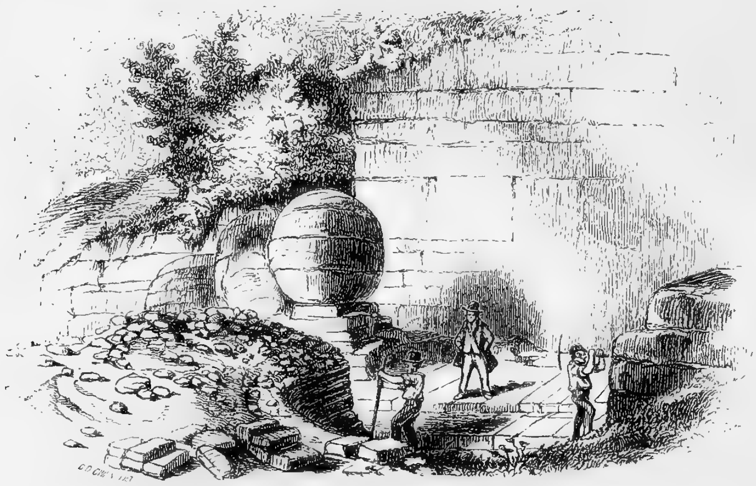
It is to be remarked, that this boundary line was, in some places, of difficult determination; and, especially in the north and west, obscure and ill-defined for considerable distances; chiefly on account of the depth and extent of the superficial sedimentary deposits.

Along the course of the Mississippi, the belt of Carboniferous Limestone cannot be traced north much beyond its confluence with the Iowa. Here it is lost beneath sandstones of the coal-measures, which appear in the Muscatine bluffs, and are remarkable, as well for the fine specimens of Lepidodendrons and Ferns which they afford (see Table VI., Figs. 1, 2, 3, 4, 5, 6, and 7), as for the globular form and great size of the curious segregations of argillaceous sandstone, which are shown in the subjoined wood-cut, as they have been laid bare in one of the quarries, half a mile below the town of Muscatine.

About five miles below the mouth of Pine Creek, these carboniferous sandstones are succeeded by limestones belonging to the Devonian period; they reappear, how-

* After crossing the Iowa boundary line into Missouri, the boundary line of this coal-field bears nearly south, through Clark, Lewis, and Marion Counties, to near the junction of the Three Forks of Salt River. Thence through the western part of Ralls County, towards the head waters of Rivière au Cuivre, in the eastern part of Audrain County, and northwestern corner of Montgomery County. Thence it sweeps, in a southwesterly curve, through Calloway County, towards the Missouri River, which it crosses near its confluence with the Osage; leaving a belt of country, some ninety miles wide, between this coal region and the outcrops at Charbonnière, and the coal-pits worked on Rivière des Pères, in St. Louis County. These are, in fact, outliers of the Illinois coal-field. From the Missouri River the boundary bears, with a westerly curve, up the valley of the Osage, north of that river, which it crosses, but for a very limited distance only, at three points: in Camden County, near the mouth of the Niangua; in St. Clair County, near the mouth of Sac River; and in Bates County, near the confluence with the main river of the Little Osage. Thence the line bears, with a northerly curve, towards the western confines of Fayette, recrossing the Missouri at Wellington; thence up the valley of that river, keeping from ten to twenty-five miles from the river, to the State line.

ever, for a short distance, on the Upper Rapids of the Mississippi, charged with *Pecopteris* (Table VI. Fig. 7), and other fossil plants. On these Rapids, near the head of Smith's Island, the carboniferous rocks finally give place to Magnesian Limestones of Upper Silurian date.



CONCRETIONS IN CARBONIFEROUS SANDSTONE, MUSCATINE.

SECTION V.

THEIR PHYSICAL AND AGRICULTURAL CHARACTER.

THE carboniferous rocks of Iowa occupy a region of country, which, taken as a whole, is one of the most fertile in the United States. No country can present to the farmer greater facilities for subduing, in a short time, wild land. Its native prairies are fields, almost ready made to his hands. Its rich, black soil, scarcely less productive than that of the Cedar Valley, returns him reward for his labour a hundred-fold. The only drawback to its productiveness is that, on some of the higher grounds, the soil, partaking of the mixed character common to drift soils, is occasionally gravelly; and that, here and there, where the upper members of the coal-measures prevail, it becomes somewhat too siliceous.

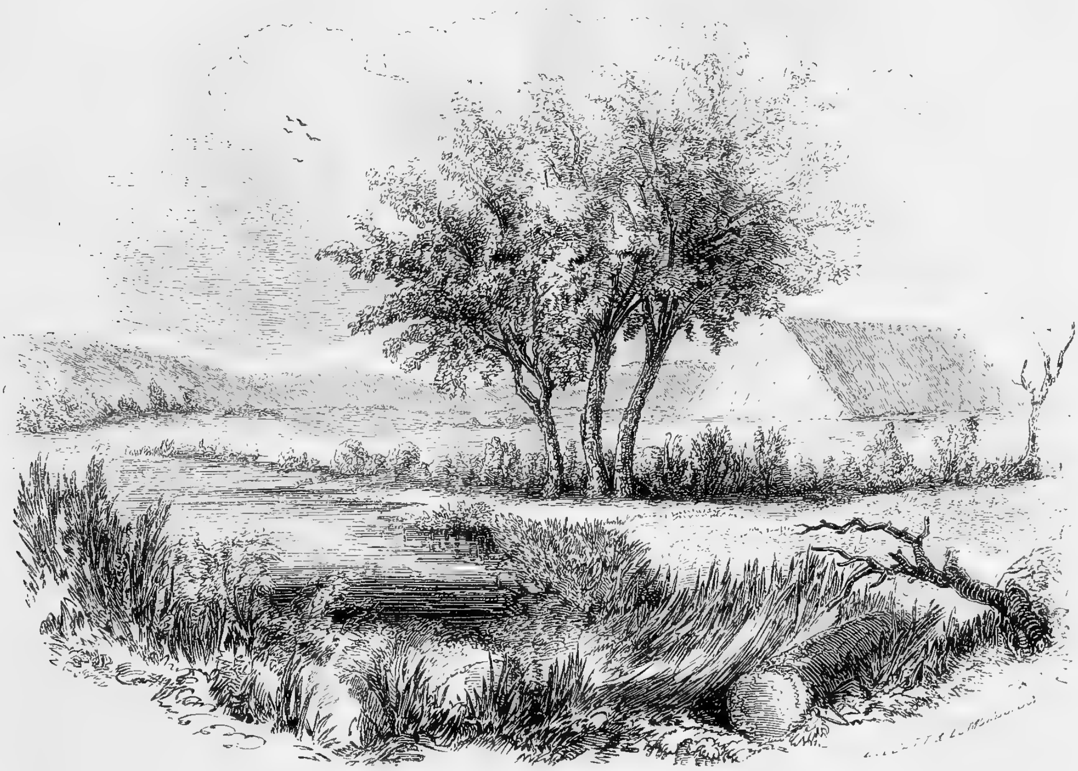
The rural beauty of this portion of Iowa can hardly be surpassed. Undulating prairies, interspersed with open groves of timber, and watered with pebbly or rocky-bedded streams, pure and transparent; hills, of moderate height and gentle slope; here and there, especially towards the heads of the streams, small lakes, as clear as the rivers, some skirted with timber, some with banks formed by the greensward of the open prairie;—these are the ordinary features of the pastoral landscape.

For centuries, the sucessive natural crops of grass, untouched by the scythe, and but very partially kept down by the pasturage of buffalo and other herbivorous animals, have accumulated organic matter on the surface soil to such an extent, that a long succession, even of exhausting crops, will not materially impoverish the

land. The prairie-sod, matted and deep-rooted, usually requires from six to eight yoke of oxen effectually to break it up.

The future farms of Iowa, large, level, and unbroken by stump or other obstruction, will afford an excellent field for the introduction of mowing and reaping machines, and other improved implements calculated to save the labour of the husbandman; and which, in new countries reclaimed from the forest, can scarcely be employed until the first generation shall have passed away.

The curious and remarkably symmetrical mound-like form of some of the outliers of the Carboniferous Limestone on the northeastern side of the basin, beyond the Forks of the Iowa, are so extraordinary, that they have been deemed worthy of illustration.



OUTLIER OF CARBONIFEROUS LIMESTONE, IOWA RIVER.

SECTION VI.

THEIR LOCAL DETAILS.

Carboniferous Rocks of the Iowa River.—After leaving Township 81 north, Range 8 west, no rocks were seen in place near the river for about fifty miles in a direct line, and nearly double that distance by the river, which is very tortuous in its course. The deep alluvial and drift deposits effectually conceal the strata on which they rest. It is only from the angular fragments of chert occasionally seen strewn on the elevated ground, that any clue is obtained to their age; this mineral

being most prevalent in the West, through the region occupied by the carboniferous and subcarboniferous limestones. It was not, however, until reaching the northwest corner of Tama County, that rocks of the subcarboniferous era were seen unequivocally in place. Here, on Section 7 or 8, Township 83 north, Range 16 west, on the left bank of the Iowa, are bluffs of one hundred and twenty-five to one hundred and fifty feet of elevation, on the slope of which both oölitic and encrinital beds of carboniferous limestone protrude; and where the river crosses the corner of Marshall County, the characteristic fossil, *Pentremites pyriformis*, was found, along with *Terebratula plano-sulcata, Spirifer striatus*, and *Productus semireticulatus*. Here, too, a change can be perceived in the outline of the country; in the greater elevation of the hills, in the increased growth of timber, and in the stiff, indurated, clayey subsoil.

It is in this vicinity that those extraordinary mound-like forms of carboniferous limestone, represented on page 101, appear as outliers, in view of the Iowa River.

In the southeastern part of Township 84, Range 15 west, on land claimed by Mr. Ballard, a thin seam of coal has been discovered, said to be about one foot thick, overlaid by shale. In consequence of the sliding of the bank, no satisfactory observations could be made, either to determine its true elevation above the river, or its thickness. From the specimens found, it appears to be of inferior quality, being much impregnated with sulphuret of iron. This is no doubt the mineral that has given origin to the reports of the existence of copper ore, on this portion of the Iowa; for, on calling on Mr. Miller, who, I was informed, had some of the copper ore in his possession, I was shown a sample of the same kind of pyrites.

In the detritus of the river, just above the first fork of the Iowa, fragments of coal are met with in the transported gravel, and below the entrance to the "Big Woods," six or seven miles above the forks, bluffs of sandstone and a highly ferruginous grit rise to the height of from one hundred and forty to one hundred and fifty feet. The latter occupies about one-third of the upper portion of the exposure, and contains from fifteen to twenty per cent. of oxide of iron, disseminated amongst a fine siliceous gravel, which, by pounding and sifting, can be separated from each other. Some portion of this ferruginous grit possesses a structure approaching to oölite. The lower part of the section is formed of conglomerates or pebbly sandstones, together with grits, having strongly marked cross-lines of deposition. Indeed, the rocks of this part of the Iowa River assume much the character of the millstone grit of the north of England, which lies between the Yoredale Series, and the coal-measures proper.

The same formation extends for several miles along the river, rising into escarpments of sixty or seventy feet, the summits of which are crowned with pines, cedars, and other Coniferæ.

Near their termination, on the right bank, where the river makes two abrupt bends, a seam of coal shows itself. It lies more after the manner of a metallic vein than a bed of coal; this arises, however, either from a dislocation, or tilting of the strata, or, more probably, from a slide, by which it appears to have been thrown nearly vertically. The confused position of the associate beds rather confirms this view.

Near the coal is a bed of dark limestone, almost black when wet, containing *Productus semireticulatus*, *Productus cora*, a new species of *Phillipsia*, and an *Eschara*.

The relative order of superposition of coal, limestone, shale, and grit, is difficult to determine, by reason of the disturbance above referred to. The coal at present lies near the edge of the water, covered with a few feet of shale, and nearly on a level with the base of the grit escarpment, which is in sight about one or two hundred yards down stream.

For two or three miles beyond the coal-bank, the hills do not present the same abrupt appearance as they do below; soon, however, the Iowa sweeps around a great easterly bend, and again washes the base of hills of sandstones, more regularly bedded than the corresponding ranges below. The oxide of iron is here not so much disseminated through the substance of the rock, but is rather collected into bands, that fill the joints and seams of stratification.

For several miles after entering the "Big Woods," the rocks are only seen at two localities, not far apart, where a reddish-yellow limestone is exposed, a few feet above the water level, while the high ground is composed chiefly of deposits of clay and sand mixed with drift, and boulders. These are the only deposits seen for twelve or fourteen miles. About latitude 42° 25′, the carboniferous limestone again makes its appearance, at first in a succession of low ledges, ten or fifteen feet above the bed of the river, sometimes on one side, and sometimes on the other, until finally they form "dalles," thirty to forty feet in elevation, between the solid walls of which the Iowa flows, with a rapid current. The limestone which forms the base of these "dalles," is of a light flesh-colour, possesses an imperfect oölitic structure, and contains a small *Terebratula*, allied to *T. laticostata*. The upper third is composed of magnesian limestones, which have much the appearance of the magnesian limestone of the Dubuque District, but cannot belong to the same period, since they form a part of the Subcarboniferous Limestone, and contain that form of *Syringopora* which M. Lesueur named *Obstringolina*, and which was found in that formation in Missouri. About the middle of this range of limestone, near a point known as "The Shower-bath," the rocks attain their greatest elevation, dipping from thence southerly and northerly as much as 7°.

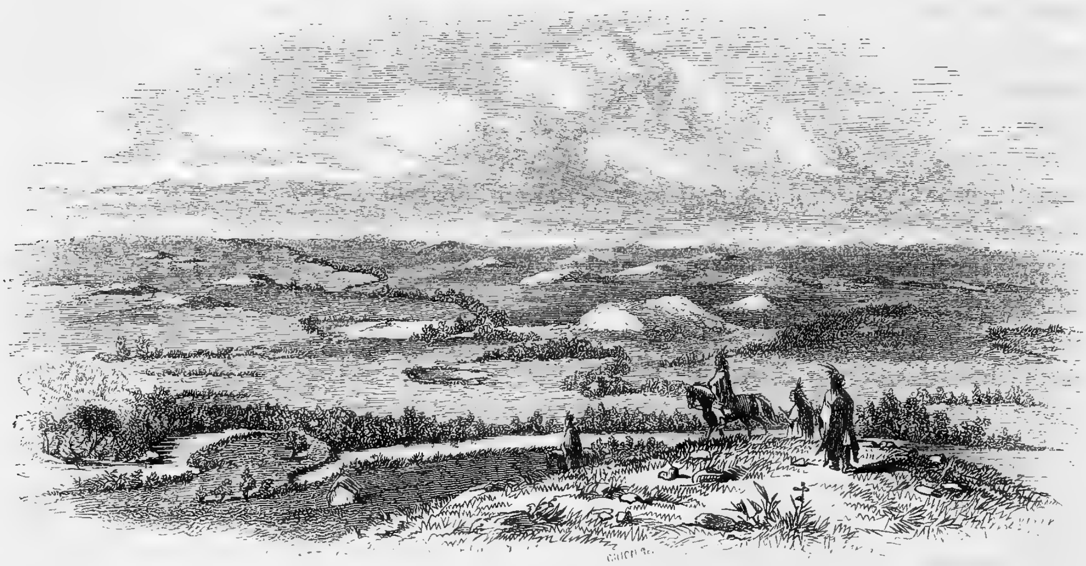
Numerous chalybeate springs issue from their base, depositing an abundant gelatinous hydrated oxide of iron.

These strata of carboniferous limestone continue, with little interruption, to the Falls or Rapids of the Iowa, situated in latitude 42° 32′ 22″. Two miles above this, the bluffs rise to the height of one hundred and thirty feet. At their base, they are composed of the semi-oölitic layers before alluded to; the coal-measures proper resting on them in the following order of superposition, from above downwards:—

	Feet.	Inches.
1. Soil and drift beds, not exposed,	90 to 100	
2. Gray argillaceous schistose sandstone,	20	
3. Bluish argillo-siliceous shale,	12 to 14	
4. Chert layer,		5
5. White siliceous rock, effervescing feebly,		4 to 5
6. White semi-oölitic limestone,		2

A short distance beyond this section, the underlying limestone rises again towards the northwest to the height of twelve or fifteen feet, for a distance of four miles, when, at a sudden bend in the river, in latitude 42° 31′ 44″, before it enters and meanders through the open prairie, the limestone pitches beneath the water level, to the northwest, and is overlapped by a mass of dark, bluish-gray, argillaceous shale. Here fragments of coal occur in the debris, though no regular bed is seen; the slide of the argillaceous layers and vegetation may conceal it from view. A quarter of a mile above, the limestone is again in place, skirting the bed of the river, and continues in low walls of five to ten feet, either on one side or the other, for four or five miles. The current of the stream becomes sluggish as it traverses low, flat land, the banks being usually only four to five feet above the river, and, even when it skirts the higher ground, these are not above five feet in elevation.

After leaving the last limestone exposure, we continued to ascend the Iowa for fifteen or twenty miles, when we finally arrived at a barren region of drift knolls stretching away as far as the eye can reach, destitute of timber, except a narrow belt skirting the Iowa River. The hollows between the drift knolls are wet and marshy, and the summit of the hills strewn with gravel and boulders, intermixed with a thin, poor soil, that only supports a scant growth of stunted herbage.



KNOBBY DRIFT REGION OF NORTHERN IOWA.

The corps whose duty it was to explore, in 1848, the southern and western tributaries of the St. Peter's River, observed towards the heads of the Mankato and Lesueur Rivers, a country of the same character which we encountered high up on the Iowa. It was hence inferred that these barren drift knolls extend beyond the northern boundary of Iowa, covering the whole water-shed that gives rise to these streams, as well as to the Iowa and Red Cedar Rivers. Seeing, therefore, no object to be obtained by a farther advance up the Iowa, and finding that our stores of provisions were barely sufficient to carry us back to the settlements, I determined

to return after making the astronomical observations necessary to determine our position, which was found to be in latitude 42° 39′ 06″.

The preceding sketch conveys a very correct idea of the appearance of this desolate region of drift knolls, as seen from one of their summits, with the wilderness of prairie stretching away to the northwest.

There remains to be said, in this place, only a few words with regard to the extreme western branches of Red Cedar, viz., Beaver and Otter Creeks, which were explored by Mr. Macy, with a view to ascertain the precise eastern boundary of the carboniferous rocks on the Iowa River.

On account of the low, wet country bordering these streams, it was only at a few points that the rocks were visible, and these only in low ledges, near the water-level, or in partial protrusions from under the mass of drift in the higher ground.

Mr. Macy succeeded, however, in detecting, in a ridge about five miles north of Otter Creek, a flesh-coloured limestone, containing that variety of *Leptæna depressa* of Dalman, which occurs in the Corniferous Limestone of New York, and is known there under the name of *Strophomena undulatus.* At a higher level in the same ridge a buff-coloured magnesian limestone was observed, in which no fossils were discovered, but which possesses the lithological character of the dolomitic beds of the carboniferous limestones found near the Iowa, a few miles below the Rapids, near latitude 42° 30′. Thus, the dividing ridge between the head waters of the extreme western branches of the Red Cedar River (Otter Creek and Elk Fork), is probably the boundary between the limestones of the Devonian and Carboniferous Eras.

In consequence of a severe intermittent which Mr. Macy contracted while traversing the low fens of this section of Iowa, exposed to the intense heat of a July sun, he was prevented from prosecuting his investigations further north.

Carboniferous Rocks of the Des Moines, below the Raccoon Fork.—The first good section exposed on the Des Moines is at St. Francisville. The Archimedes limestone occurs here, a few feet above low-water mark; and upon it rest several members of the Carboniferous Limestone, in the order represented on Section No. 4, D.*

The geodiferous beds which immediately overlie the Archimedes limestone, are here mostly concealed by the alluvion of the Des Moines, and the talus from the superior strata. The St. Francisville quarry affords, however, a good opportunity of examining the buff-coloured rock, which lies about fifty feet above the bed of the Des Moines, with a face of about ten feet exposed. It is at present obtained here, for the construction of the public works in the vicinity, in large blocks, from two to three feet thick. This rock is of a decided dolomitic character, yielding by analysis thirty-seven per cent. of carbonate of magnesia, and fifty-six per cent. of carbonate of lime. Its specific gravity is considerably below the average of common limestones, being but 2·589; a property which must be considered an advantage, regarding it as a building material. Its durability has not been fully tested; but

* The Sections in this chapter designated as No. 1, D, No. 2, D, &c., are the Sections on the Des Moines River.

its chemical composition is a favourable indication that it will withstand atmospheric vicissitudes. *Gorgonia reteformis* seems to be its principal organic contents. Thin, and thick-bedded argillaceous and siliceous sandstones are interposed between this rock and a fine-textured, brittle, fragmentary limestone (d'), which forms the upper part of the section, and contains ninety per cent. of carbonate of lime.

The most southern coal-bed which I was able to discover lies on the southeast quarter of Section 23, Township 66 north, Range 7 west, of the 5th Principal Meridian, in the valley of a small creek. Near the water, the concretionary and fragmentary limestone (f'), as shown on Section No. 5, D, is seen underneath slaty clay and shale, with impressions of *Calamites*. On this rests the coal-bed, which is only one foot thick, and of inferior quality, being slaty in its structure, and much impregnated with pyrites.

The strata at this locality must have suffered considerable disturbance, since, only a few hundred yards down the stream, on the north side, the limestone rises to the height of thirty feet, having a considerable southeasterly dip. A little lower down, a rock, similar in appearance to the building-stone in the St. Francisville quarry, rises to the surface.

Near Dam No. 2, on Section 11 (?), Township 66 north, Range 7 west, of the 5th Principal Meridian, the magnesian quarry rock is at an elevation of twenty-five feet above the bed of the river, as shown on Section No. 6, D. At the northwest end of the quarry a partial bed of shelly limestone is interposed, in a wedge-shaped manner, in the midst of the thick-bedded limestones; the former is full of *Gorgonia reteformis;* the latter is partly a brown and buff-coloured, cellular, magnesian limestone, and partly a banded and more argillaceous rock.

A few miles above Dam No. 2, at a place called Sweet Home, the residence of Mr. Harlem, is a hill composed chiefly of close-textured limestone (d'), with thin beds of marly clay between the layers. Masses of *Lithostrotion*, a specimen of which was presented to me by Mr. Harlem, are found in the bed of Cedar Creek, which washes the base of these limestones. Just above the mouth of that creek, in the bed of the Des Moines River, is a gray limestone, containing *Productus semireticulatus*, and *Spirifer striatus* (?). The upper portion of this section shows the irregular, fragmentary, and concretionary limestone, with beds of argillaceous, marly limestone beneath, at an elevation of thirty-five feet above the channel of the creek.

On Tremble Creek, northwest quarter of Section 8, Township 66 north, Range 7 west, a poor seam of coal has been discovered; also on Section 16, Township 66 north, Range 8 west, two miles south of Peevler's Branch, and at other localities along the same water-course. A bed of better quality, supposed to be three feet thick, has been observed in the high prairie, on the east half of the northeast quarter of Section 36, Township 67 north, Range 8 west, two miles from the Des Moines River. On the head of the Chariton River there is said to be coal of good quality.

One mile above Farmington, on Section 24, Township 68, and Range 8 west, five seams of coal succeed one another, with shales, clays, and sandstones interposed, in the following descending order:

		Thickness of Bed. Feet.	Inches.
1.	White, brown, and yellow sandstone,	12	
2.	Shale and imperfect coal,	1	
3.	Argillaceoous bed (fire-clay ?),	16	
4.	Coal,		8
5.	Sandstone,	5	
6.	Fire-clay,		16
7.	Main coal seam,	$2\frac{1}{2}$ to 3	
8.	Fire-clay,	3	
9.	Coal,		18
10.	Slaty clay,	5	
11.	Coal, not yet penetrated,	(?)	

The two upper seams in the above are too thin to be productive. Whether the lowest be worth working has not yet been ascertained.

At the above locality, two drifts have been run into the hillside to the distance of sixty yards, and a good deal of coal removed from beds Nos. 7 and 9, for the use of the neighbouring town of Farmington. Bed No. 7 is of tolerable quality, furnishing a slaty, bituminous coal, of a mottled dull and bright fracture on the horizontal surface; the dull portion displaying distinctly the ligneous fibre, and presenting the aspect of charcoal. This latter character is common to most of the coal-beds in the Des Moines country.

In the eastern drift there is a fault, having a hade of about 45°; the walls of which present the semi-polished surface, popularly known among miners as "slickensides."

About half a mile to the south of the coal mines, where several wells have been sunk for the use of a brickyard, there is additional evidence of small, local depressions, and uplifts, such as appear to have taken place along the whole course of the Des Moines River, at short intervals, as far as the coal formation has been traced, bringing certain members at one time to the surface, and again depressing them beneath the water-courses. At the depth of eighteen to twenty feet, in three of the wells, a bed of coal was struck, supposed to correspond to 4 of the section, while in two other wells, situated from one hundred to one hundred and fifty yards to the east, black slate was struck at the depth of eleven feet, with a nine inch-seam of coal under it, composed largely of absolute charcoal, with the ligneous fibre even more distinctly shown than in the White River coal of Indiana.

On the opposite side of the Des Moines, near Indian Creek, on Section 34, same township and range as the preceding locality, coal has also been struck, just under the surface-soil and drift, pitching east of north; though the strata on the other side of the ravine dip in a contrary direction. Mr. Babcock, the owner of the land, has laid open the bed to the depth of four or five feet.

Two feet beneath where the coal was first struck, there is a bed of fire-clay, of about ten inches in thickness; and beneath this again, a twenty inch-seam of fair coal. The parting of fire-clay, and the quality and thickness of coal above and

below the same, warrant the opinion that this coal, though at a lower level, corresponds to coal-beds Nos. 7 and 9, near Farmington.

Discoveries of coal are reported to have been made on Indian Creek, and at a point about three-quarters of a mile below Farmington, and one mile west of the Des Moines.

At a mill-site on Indian Creek, about three-quarters of a mile above its mouth, no coal is visible; the section presenting the following members only of the upper carboniferous limestone series, all below the coal-beds:

	Feet.
1. Overhanging ledges of sandstone, cellular and rugged at base (*c'*), .	15
2. Concretionary masses of impure magnesian limestone and blocks of sandstone; crystals of selenite disseminated; marly earth in the interstices (*b'*),	15
3. Band of same, more regularly bedded, ...	5
4. Soft, marly, and argillaceous beds, ...	5
5. Top of the geodiferous beds exposed (*a'*).	

The member *b'* is here much more irregular, both in composition and structure, than is usual; and, at this locality, it is useless for the purposes of construction. Two miles above Farmington it is much more uniform and solid; though a portion of the rock has that peculiar tubular and cellular structure, by which it is characterized at several localities higher up the Des Moines.

On the waters of Indian Creek, near a Mr. Wilson's, there is said to be coal; but I had no opportunity personally to examine it.

About half a mile from the Des Moines, near the line between Sections 25 and 26, Township 68 north, and Range 8 west, of the 5th Principal Meridian, on the farm of a Mr. Slaughter, a seam of coal is worked, about two feet in thickness, and occurring on elevated ground, within a few feet of the surface, it is covered by bituminous shale and soil. The quality is equal to that of any of the seams heretofore noticed.

The beds which immediately underlie it are not exposed; but, a few rods from the coal-pit, fifteen or twenty feet down the descent of a steep hill, limestone shows itself; and at a quarry a few hundred yards further, Section No. 10, D, is exposed.

The various members, however, will be more distinctly recognised in the following table:

	THICKNESS OF STRATA.	
	Feet.	Inches.
1. Even-bedded limestone (*f'*), ...	$2\frac{1}{2}$ to 3	
2. White gritstone (*e'*)	2 to 3	
3. Marly, schistose layers, with silicate of iron, ...		6
4. Compact and obscurely oölitic white and light-gray limestone, .	12 to 13	
5. Concretionary magnesian limestone, ...	7 to 8	
6. Cellular, close-textured, concretionary limestone (*d'*), . .	5	
7. Buff and flesh-coloured, close-textured, magnesian limestone, .	20	
8. Concretionary magnesian rock, mixed with marl, . .	7	
9. Pebbly sandstones (*c'*), ...	4	6
10. Limestone containing *Aulopora* forms the bed of the creek, .	(?)	

Passing from Farmington to Bonaparte, there is a rapid rise of the strata. Already, at Dam No. 4, the cellular magnesian limestone (b') appears above the water-level; and, in the quarries below Bonaparte, the shell-beds (e'), charged with small *Spirifer striatus*, are found from fifteen to twenty feet above the water-level; while at twenty-two to twenty-three feet numerous elliptical stems of *Platycrinus*, such as occur on the Mississippi, at the Keokuk Rapids, present themselves. These are associated also with the same species of *Cyathophyllum*, *Ancella*, and *Gorgonia*, that characterize the rocks at the last-mentioned locality.

Just below Bentonsport, the different members of the lower series of carboniferous limestones rise to more than 80 feet above the river; the geodiferous beds (a') of the upper series only capping the tops of the hills under the sub-soil.

The strata near the middle of this section (No. 11, D) are charged with *Orthis umbraculum*, while *Archimedes* and *Spirifers* are most abundant in the upper ledges.

At fifteen feet from the base of the section, a chert-bed, eighteen inches thick, separates the *Orthis* beds from white, crystalline, encrinital limestone (containing *Spirifer striatus*) lying beneath.

At several localities in Van Buren County, four or five miles from Bentonsport, in Township 69 north, Ranges 8 and 9, beds of coal have been discovered, varying in thickness from twenty inches to two feet. That which was esteemed the best by the blacksmiths, in 1849, was the bed owned by a Mr. Jackson, and the coal procured on the west side of the waters of Bear Creek, owned by Messrs. Davis, Thomas, Leech, and Christian.

At the quarry, one mile above Bentonsport, on Section 33 or 34, Township 69 north, Range 9 west, a gravelly sandstone is found, like that in Slaughter's Branch, at an elevation of about seventy feet, underlaid by chert and marly beds. The magnesian quarry rock is also seen here at a little lower level, with a band of argillaceous rock (that has the appearance of hydraulic cement rock) intervening between it and the marly limestones. Three miles above this quarry, the gravelly sandstone is only thirty-three feet above the water-level, and separated from a fragmentary limestone by eighteen inches of marlite. At two separate locations, below Keosauqua, one on the west, and the other on the east side of the Des Moines, the cellular magnesian limestone is twenty to twenty-five feet above the river, overlaid by concretionary limestone; as may be seen by inspecting Section No. 12, D.

At Gillis's coal-bank, on the east half of the southwest quarter of Section 32, Township 69 north, Range 9 west, about two miles below Keosauqua, these same beds are seen, at a little lower level; the pebbly sandstone being near the water-level. Over the upper concretionary limestone are ferruginous clays, and on these rests a coal-seam, eighteen inches in thickness, as shown in Section No. 13, D. This seems to be the lowest coal-bed in the Des Moines Valley, and lies about twenty feet above the concretionary limestone f'.

Beds of coal have been observed at various localities in the vicinity of Keosauqua. The best, however, is said to be obtained between the Des Moines and Skunk Rivers, in the neighbourhood of Fairfield, on the waters of Walnut and Cedar

Creeks, in Jefferson County. Three beds were there examined by Dr. Shumard, who describes them as corresponding with beds numbered 2, 3, and 4, in Section 9, D.

In the ravines immediately northeast of Keosauqua, ten feet of sandstone is visible, with five or six feet of magnesian limestone superimposed. This latter becomes concretionary, as it passes upwards into a white, compact, purer limestone, containing a small *Terebratula* and *Spirifer*. (See Section No. 14, D.) In digging wells at this village, limestone is struck after penetrating the subsoil; and water is obtained on reaching the underlying sandstone.

In reviewing the modifications of the different members of the Upper Carboniferous Limestone Series, as they present themselves at various points between the Mississippi and the great bend of the Des Moines, in which Keosauqua is situated, though there be a certain degree of persistence in the members, still one can trace, even in short distances, considerable modifications, not only in the thickness, but also in the composition of the rock.

An example of this occurs on the south half of Section 26, Township 68 north, Range 8 west. There, eight feet of sandstone (*e′*) can be seen under the upper concretionary limestone (*f′*), while on the north half of the same Section, the bed has shrunk to a thickness of but two feet and a half.

Again: on Section 29, Township 69 north, Range 9 west, twenty feet of gritstone (*e′*) intervene between the Upper and Lower Concretionary Limestones (*d′* and *f′*); while on Section 32 of the same township and range, the layer of gritstone attains a thickness of some two or three feet only; and that, too, so blended with the limestone above and below, as to be hardly recognisable as a distinct member.

So, also, on Section 32, Township 66 north, and Range 6 west, as well as on Sections 12 and 13, Township 67 north, Range 7 west, the magnesian building-stone *b′* occurs in a solid mass, eight, ten, even twelve or fifteen feet thick; while on Sections 33 and 34, Township 68 north, and Range 8 west, it becomes so concretionary and so mixed with sandstone, that it is with difficulty it can be recognised.

Yet again: the pebbly gritstone, which, in one of the quarries on the bluffs of Nassau Slue, is eight feet thick without a seam, diminishes on Sections 27 and 34, Township 65, Range 5, to four feet in thickness; while on the Des Moines, in Township 68, and Range 8, and some other localities, it seems to be wholly deficient.

These variations in the thickness, structure, and composition of the different members of the Upper Carboniferous Series, ought to be closely noted by persons selecting materials for construction, in the district where this series prevails.

On Indian Creek, two miles and a half from the State line, probably in Section 2, Township 67 north, and Range 9 west, ten to twelve feet of brown sandstone reposes on sixteen to eighteen feet of concretionary limestone (*d′*).

Passing from the Des Moines west towards the waters of the Fox and Chariton, rocks are much less frequently seen exposed on the surface than on the Des Moines and its tributaries; and the inhabitants of that portion of Iowa have often difficulty in procuring water, even at considerable depths. This may probably be attributable

to the westerly dip of the strata, carrying the impervious argillaceous beds down, whilst the water filters freely through the superincumbent sandstones.

In the neighbourhood of Portland, which is sixty-six miles by water, above the mouth of the Des Moines, coal is found in several places. On the north corner of the northwest quarter of Section 25, Township 70 north, Range 11 west, about thirty-five feet above low water of the Des Moines, a seam four feet thick shows itself, just above the bed of Doud's Creek, resting on a bed of tenacious clay, and covered by the subsoil of the creek bottom; also at several other places on the same creek, indicating an easterly dip of ten to fifteen feet in three-quarters of a mile. On a branch of the same creek, this coal is again seen, covered with six feet of sandstone, as well as on Section 24, at the forks of the same branch, and on the northeast quarter of Section 25. On the northeast quarter of Section 10, Township 70 north, Range 11 west, at a much higher elevation, is a pretty fair quality of coal, on Mr. Walker's land. On the west side of the Des Moines, on the waters of Holcomb's Creek, some little coal shows itself; on the same stream, also, there are a few licks of brackish water.

In the bed of the Des Moines, nearly opposite Iowaville, coal is found below the water-level; and two miles south of Iowaville, is a bed of coal owned by Mr. Miles. One and a half miles from the river is another, belonging to Mr. Campbell; besides which, it occurs at many other places in the neighbourhood.

On Section 14, Township 70 north, Range 12 west, on the farm of Mr. Jacob Carter, is a weak brine spring, which, with nitrate of silver, affords a white, curdy precipitate, insoluble in nitric acid, but soluble in ammonia, and also gives with chloride of barium a white precipitate, only partially soluble in nitric acid. Acetate of lead does not give a black precipitate, nor even darken the water, but yields only a white precipitate, consisting partly of sulphate and partly of carbonate of lead. Both ammonia and carbonate of ammonia give merely a white precipitate; while hydrosulphuret of ammonia gives no immediate appreciable precipitate. The water deposits a copious brown, gelatinous, hydrated oxide of iron, mixed with a little carbonate, which, when dissolved by acid, strikes a deep Prussian blue with ferro-cyanide of potassium, and black with hydrosulphuret of ammonia; indeed, this latter reagent gives an instantaneous blackness when merely dropped on the brown deposit as it settles from the water. Ten or twelve other brine springs occur on Section 17, Township 70 north, Range 12 west, which give similar reactions with chemical reagents. Of those which I tested, that on Section 17, Township 70 north, Range 12 west, gave the most copious precipitate with nitrate of silver; but none of them can be regarded as strong brines. In the Introduction, I have given the reasons why I considered it doubtful whether, by boring, a profitable brine could be procured.

The constituents of these waters are: chloride of sodium; chloride of magnesium; bicarbonate of iron;* bicarbonate of lime; sulphate of soda; sulphate of magnesia; with perhaps some other ingredients in small proportion, as bromides and iodides; but not having received a supply of the water, as I expected, to submit it to rigid analysis in my laboratory, I am not able at present to give any more definite information regarding these saline springs.

* Precipitated almost as soon as the water reaches the atmosphere.

All along the eastern margin of the Illinois and Indiana coal-field, as well as the western margin of that portion of the same basin, which stretches through Ohio, Kentucky, and Tennessee, where productive salt-works have been established, the base of the coal formation, down to the Archimedes, Pentremital, and Oölitic limestones, is arenaceous, and the borings for salt water at these localities have uniformly been carried through porous and cellular sandstones with vegetable impressions. The lower members of the Iowa coal-field, as has been already stated, consist chiefly of calcareous rocks, especially around the southern and western margin of this basin on the Des Moines and Missouri Rivers. In this respect the Iowa coal-measures differ essentially from those of Ohio, Virginia, Kentucky, and Indiana.

This fact serves to clear up a difficulty which has hitherto existed with regard to the true geological position of certain limestones in the vicinity of St. Louis, which are now shown to form that portion of the Carboniferous Limestone Series, which is known in Yorkshire as the Upper or Yoredale Series, and is one of the last members (*d′*) of the Upper Carboniferous Limestone of Iowa.

At several localities in the neighbourhood of the brine springs above mentioned, at an elevation of ten or twelve feet above the springs, is a bed of limestone, having hydraulic properties, and an argillo-calcareous rock, presenting that peculiar concentric, crimped, conical structure, known in Germany by the name of *Tutenmergel*, and usually attributed to a shrinkage of the strata. It may, however, in my judgment, be more correctly referred to an imperfect crystallization, produced by a process of infiltration through beds of marly, argillaceous matter; since I found the structure displayed in greatest perfection higher up on the Des Moines, in a band of three or four inches of calcareous spar, possessing an arragonite structure, included in marly shales; the concentric conical surface having only a thin superficial coating of earthy matter, apparently carried down mechanically during the passage of the calcareous matter through the argillaceous matrix.

In connexion with these beds are thin seams and isolated crystals of selenite, the whole being covered by argillaceous slaty clays. Sandstone is found in the higher grounds, but its junction with the inferior beds cannot be satisfactorily seen at this locality.

The dark, bluish gray, earthy variety of hydraulic limestone* contains 63·5 per

* Analyses of two varieties of hydraulic limestones, from the Saline Branch of Soap Creek, gave the following results.

	Dark Earthy.	Light Gray.
Water of absorption,	001·5	001·
Silica,	15·5	053·
Carbonate of lime,	63·6	029·9
Magnesia,	1·2	7·4
Alumina,	8·3	6·2
Protoxide of iron,	7·4	1·8
" manganese,	·4	trace
Soda,	·4	·6
Potash,	·3	trace
Loss and bituminous matter,	1·4	·1
	1000	1000

cent. of carbonate of lime, 15 per cent. of silica, and 7·5 per cent. of oxide of iron, which exists in the state of protoxide; the light gray, less than half the quantity of carbonate of lime, 53 per cent. of silica, and not quite 2 per cent. of protoxide of iron. It is much inferior in quality to the dark, earthy variety; indeed, it is hardly entitled to be considered hydraulic.

Towards the mouth of Soap Creek, are good sections of the middle argillaceous division of the coal-measures. On Section 3, Township 70 north, Range 12 west, three seams of coal are seen in the midst of a mass of bituminous shale, as shown on Section No. 19, D. The two lower seams are the thickest, being about two feet each. The coal is slaty in its character, and presents the appearance of charcoal on the cleavage surfaces. The strata pitch with an irregular dip to the northeast, so that the corresponding beds are considerably lower on the Des Moines River, opposite the mouth of Soap Creek—a distance of a mile and a half—than they are at this locality.

Two miles above the mouth of Soap Creek, at "Cedar Bluffs," on the Des Moines, heavy beds of sandstone, constituting the lower members of the upper division of the coal-measures, overhang the shaly beds, and rest immediately on an inferior thin seam of slaty coal, charged with sulphuret of iron, passing rapidly into the state of sulphate of iron. The latter appears in the form of light green crystals, efflorescing from the edges of the coal, which are protected from rain by the projecting ledges of solid gritstones. Thin carbonaceous seams and specks are disseminated through the inferior beds of sandstone, together with imperfect vegetable impressions. Thirty-five feet of sandstone is exposed at this locality. (See Section No. 20, D.) There are probably two or more seams of coal hidden from view in the slope by the rubbish, which conceals from twenty to thirty feet of the lower part of the Section. The shale contains some calcareous bands and septaria; some of which may have hydraulic properties. From the cavities of these, very regular crystals of calcareous spar were obtained.

Near the mouth of Turkey Creek, light buff sandstone, containing irregular veins of carbonaceous and coaly matter, lie within two feet of the water, and extend to the height of twenty-five feet; the rock is filled also with imperfect impressions of *Calamites*, *Sigillariæ*, and *Equisetaceæ*. Some of the beds are irregularly schistose, others sufficiently thick to afford a tolerable building-stone, if fairly quarried into.

From one and a half to two miles below this, close-textured, light-coloured limestone was observed in the bed of the river, with a schistose sandstone near the water-level. On Sugar Creek, a few rods above its mouth, there are solid ledges of limestone running across the bed of the river, with an easterly dip, forming a fall of about two feet. On Section 28, Township 72 north, Range 13 west, on the same Creek, and at the water-level, is a seam of coal, three feet thick, overlaid by two and a half feet of dark gray, bituminous limestone. In digging a well at Mr. Farlin's house, near by, an eighteen-inch bed of coal was struck, which, by estimation, must lie about five feet above the afore-mentioned limestone. Both beds of coal rest on shale, and the upper bed is covered with eight feet of the same material. The rock in the hills above is chiefly sandstone, with a bed of coal and shale immediately

beneath it. The same limestone which is found on Sugar Creek, near its mouth, forms the bed of the river at Ottumwa, and the rapids below that place.

At Dam No. 15, on Section 9, Township 72 north, Range 14 west, white and yellow sandstones extend four to six feet above the water-level, with alternations of limestone and shale, as above represented on Section No. 25, D. The middle beds of limestone contain *Spirifer striatus, Terebratula sacculus* (?), *Terebratula Roissyi,* and an undetermined *Terebratula.* The shelly beds contain *Productus cora,* and another Productus nearly related to it.

On Section 5, Township 72 north, Range 14 west, the river runs over smooth ledges of limestone, which are seen above the water-level on Section 6, as well as below the mouth of Avery Creek, in the southwest corner of Section 30, Township 73 north, Range 14 west, at which place it has a very irregular fracture, and rough surface, the edges being stained with a metallic oxide, probably manganese. This rock appears to be the same bed that forms the upper portion of Section No. 25, D. The strata rise about six feet between the mouth of Lower and Upper Avery Creeks. On Section 22, Township 73 north, Range 15 west, six feet of limestone, containing *Spirifer striatus,* and *Terebratula sacculus,* rest on marl; one of the layers, six feet above the water-level, is oölitic. There is said to be a thick bed of coal on Rocky Run; which, however, I had no opportunity of examining.

At Dam No. 17, the Des Moines has a rocky bottom of limestone, which just shows itself above the water-level, and rises six feet above it on Section 17, half a mile further up overlaid by sandstone. The top of the marl-bed is also seen here, about eight feet above the river. The exact position of the sandstone is not clearly seen, as it lies in loose slabs, somewhat out of place.

Three miles beyond Eddyville, in the bluffs of Muchakianock Creek, near the line between Sections 19 and 30, Township 74 north, Range 15 west, is Morgan's coal-bank; here there are about four feet of tolerable coal, with only a few inches of shale between it and the overlying sandstone, the whole resting on argillaceous shale. This coal-bed seems to correspond with the upper one on Sugar Creek; if so, it increases in thickness and improves in quality towards the northwest. Coal has been discovered also on Bluff Creek, and other places in the vicinity, and is probably the same bed.

This coal, though applicable to ordinary purposes, is not of a quality sufficiently pure to enable the blacksmith to work up and weld steel with it.

Thin beds of limestone are exposed on the right bank of the Des Moines, above Eddyville. At Dam No. 18, sandstone extends from the water's edge to three or four feet above, with an undulating dip, overlaid by three or four feet of limestone similar to that found at Dam No. 15.

On Section 1, Township 74 north, Range 17 west, a light gray limestone is exposed, stained of a flesh-colour in the joints; in it I found the defensive fin-bone of a fossil fish, but it was not sufficiently perfect to enable me to make out the species. No sandstone is seen here; neither has any coal yet been discovered nearer than Bluff Creek, on Section 14, Township 74 north, Range 17 west.

The middle divisions of the coal-measures gradually decline above the last section, so that the upper division extends within twenty-five feet of the water-

level, rising in a conspicuous bluff of seventy to eighty feet perpendicular, known as "Raven Cliff," which is composed entirely of buff, yellow, and brown sandstones. This is on Section 32, Township 75 north, Range 17 west. The strata on which it rests are effectually concealed.

At the bend of the Des Moines, on the same section on which Raven Cliff is situated, just below the mouth of Cedar Creek, limestone comes again to the surface, with the marl-bed beneath, just seen above the water-level. On the northeast of the same section, is a seam of coal, twenty to thirty inches in thickness, and some twenty-five to thirty feet above the water-level of the Des Moines. There is supposed to be another bed of coal, near high-water mark, but it is not at present accessible. In the bed of a creek near the mouth of Cedar, is a ferruginous calcareous rock, which was supposed by the settlers to be iron: it contains, however, too small a percentage to rank as an iron ore; but on the same branch is also found a conglomerate of oxide of iron, and it is not improbable that some workable band of ironstone might be discovered by stripping the bank.

It is evident, from the exposures near the mouth of Red Cedar, that there must be considerable elevation of the strata, soon after passing Raven Cliff, otherwise the limestone and argillaceous deposits could not be found so high above the water-level.

At Talley's Ford, or Belle Fontaine, a cherty limestone forms the bed of the Des Moines, while above the water-level are alternations of limestone and sandstone.

From this place an excursion was undertaken to Cedar and Honey Creeks, for the purpose of examining the coal, and ascertaining the origin of the reports of lead ore having been found in considerable quantities in the vicinity.

On Section 2, Township 74 north, Range 18 west, on the right bank of Cedar Creek, is a bed of coal, from twenty inches to two feet in thickness, under a bed of sandstone, and resting on shales and shaly sandstone.

On Section 12, Township 74 north, Range 18 west, on a branch of the same creek, a bed of coal, nearly three feet thick, exists at about the same level. On Section 16, same township and range, at a height of fifteen to twenty feet above the bed of the run, is a five-foot seam of good coal, which can be used for working cast steel. On the north fork of the south branch of Cedar, on Section 30 of the same township and range, there is coal of pretty fair quality, four to six feet thick, covered by sandstone. On Rosseau's Run, Section 23, same township and range, ten feet above the channel, a bed of ligneous coal, from eighteen inches to two or more feet in thickness, rests on potter's clay (see Section No. 28, D.) A little further down this run is a seam of coal, five to six inches thick, covered with ash-coloured clay, approaching the character of fire-clay, but more gritty. This coal lies about three feet above the bed of the run, and is considered to occupy a position inferior to the two-foot seam before-mentioned; the strata having a rise of six feet in a hundred yards towards the west. Indeed, at one point on the run, two beds can be seen, lying about eight feet apart. Numerous rootlets of *Stigmaria* were observed, interlaced in the argillaceous beds. On Section 14, same township and range, a two-foot seam of coal rests upon fine gritstone one foot thick, contain-

ing *Stigmaria*. Thin beds of coal show themselves at several other places on Rosseau's Run, as well as at the following localities in this neighbourhood. A bed of inferior quality, two and a half feet thick, occurs on Section 4, Township 74 north, Range 18 west; another, two to three feet thick, on Section 6, Township 74 north, Range 17 west; and on White Breast River is a three-foot bed of pretty good quality, on Section 3, Township 75 north, Range 20 west, three to five feet above the water-level.

On Section 15, Township 74 north, Range 18 west, on Cedar Creek, a laminated sandstone, containing *Lepidodendron Sternbergii*, is seen extending ten or twelve feet above the water-level, overlaid by argillaceous shale. The latter contains many crystals of selenite, some of which are regular rhomboidal prisms, with the edges bevelled. Immediately under the range of selenite, the *tutenmergel* structure is apparent in the argillaceous beds. The same members present themselves on Honey Creek, on Section 35, Township 75 north, Range 18 west. This is the locality where diggings were undertaken in search of lead ore, but without any success, so far as I am able to judge, both from personal inspection and the most reliable information. The attraction on Honey Creek was doubtless the brilliant, yellow, metallic lustre of iron pyrites, disseminated in the dark, argillaceous shales, in connexion with the transparent crystals of selenite, which, under the general appellation of "*tiff*," was taken to be a sure indication of the vicinity of rich veins of galena. Nothing could be more unfavourable to the presence of profitable veins of that ore, than the schistose crumbling beds of argillaceous shale that crop out everywhere in the vicinity. A far more likely source of sulphuret of lead would be the underlying hard limestones, which, however, do not reach the surface in this vicinity. Yet even they are not likely to prove metalliferous in this district of Iowa, for reasons heretofore stated, and because there are no symptoms of outbursts of igneous rocks throughout this region, either in the shape of basaltic dykes, toadstone, or whinsills, such as traverse the mining districts of the carboniferous limestone of other countries. On the contrary, the landscape presents those gentle swells, dotted with groves and intersected with belts of timber, that form so characteristic a feature of the rich farming lands bordering the valley of the Des Moines; their wavy outline is seldom interrupted, except in the immediate vicinity of a water-course, by the protrusion of even a solitary ledge of rock, that might furnish a few slabs to wall a cellar or underpin a building.

After examining this section of country, and endeavouring to trace the reported discoveries to their origin, I became pretty well satisfied that the small quantities of lead ore which have been found, either at the designated locality on Honey Creek or elsewhere in the vicinity, consisted of a few pieces, brought most probably into the country by Dubuque miners, and placed in the earth as a trick, or for the purpose of deception, in order to obtain money under false pretences.

The geological formation of the Des Moines River, and its branches in the south-eastern part of Marion County, corresponds in many of its features with that of the northern part of Davis County. The selenite, at both localities, occupies the same relative position, just above the dark argillo-calcareous deposits, possessing a *tutenmergel* structure, and associated with *Septaria*, and isolated masses having the com-

position of hydraulic limestone. On Section 7, Township 75 north, Range 17 west, is a heavy bed of very dark argillaceous limestone, displaying the *tutenmergel* structure in great perfection. It is quite probable that this rock may prove a good water limestone.

Near the mouth of English Creek are thin-bedded limestones, with yellow stains and dendritic markings, which are probably subordinate to the strata hitherto described in the vicinity. On Section 30, Township 76 north, Range 18 west, above Dam No. 22, slabs of a similar limestone are seen associated with sandstone. A sudden rise of the waters of the Des Moines covered all but the upper strata, which prevented a satisfactory examination into the exact order of succession at this and several other localities higher up.

Near the line between Sections 14 and 23, Township 76 north, Range 19 west, a mile and a quarter below the mouth of White Breast River, there is an outcrop of coal, known as "Babet's Coal-Bank," which appears to be from four to five feet thick; it rests on laminated, argillaceous sandstone, and is covered by shale and earth. A ravine intersects the exposure, which marks the place of a slide, so that the bed of coal, at the lower part of the exposure, lies much nearer the water than beyond the ravine. The section No. 29, D, represents the position of the coal at this place. The rubbish which forms the talus hides the lower strata, and may conceal also an inferior bed of coal. The blacksmiths in the neighbourhood have used some of this coal, and esteem it next in quality to the three-foot seam in Jasper County, near Skunk River; it seems tolerably free from iron pyrites, but it is slaty in its structure.

On Section 11, same township and range, one and a half miles below the mouth of White Breast River, is another exposure of coal, as well as at many places in the banks of streams tributary to the Des Moines. Near the line between Sections 10 and 15, on White Breast River, a quarter of a mile from the Des Moines, sandstone rise twenty feet above the water-level. There is supposed to be a seam of coal under this sandstone; if so, we have here, in all probability, the same beds as seen in the section at Cedar Bluffs.

Two miles above the mouth of White Breast River, on Section 8, Township 76 north, Range 19 west, light-coloured limestone is seen in the bed of a run, alternating with sandstone; and at Elk Bluff, a little higher up, are precipices of solid beds of yellowish and reddish-brown sandstone, sixty to eighty feet high, dipping towards the west; and only a few hundred yards above, at Dam No. 24, there is a repetition of the same limestone and sandstone, seen two miles above White Breast River. Here is evidently a considerable fault, perhaps of one hundred and fifty feet, by which the limestone is thus suddenly brought to the surface, contrary to the general tendency of the dip of the heavy beds of sandstone forming Elk Bluff.

On Section 35, Township 77 north, Range 20 west, a quarter of a mile above Red Rock, is a high cliff of red sandstone, from which the place takes its name. The oxide of iron which forms the cement of the upper ledge, is in a high state of peroxidation, as if it had been exposed to igneous action in contact with oxygen or atmospheric air. The deep red colour penetrates the substance of the rock, showing that it is not due to the combustion of the dry herbage of the forest. The

lower beds differ but little in colour from the ordinary reddish-brown and yellow sandstone of the country. On the left bank the ridges of sandstone attain the height of eighty-five feet above high-water of the Des Moines. The upper beds, and those of the deepest red tint, are so soft as almost to crumble under the pressure of the hand. Some of the brown sandstone, on the contrary, is hard enough to strike fire with steel. There seems to be a northwesterly dip of the beds, of a few degrees, but as it strikes back into the bluffs, it cannot well be observed. Some of the strata are marked by cross-lines of deposition, others are banded with variegated stripes of red and yellow.

Though differing somewhat in colour, the sandstone of Red Rock occupies, in all probability, the same geological horizon as that which forms Raven Cliff and Elk Bluff.

These cliffs of sandstone continue only for a short distance beyond Red Rock. Near the mouth of Calhoun Creek, the base of the hills is composed chiefly of argillaceous strata, enclosing a six-foot bed of sandstone, and an imperfect seam of coal, together with crystals of selenite and bands of ironstone, in the order here shown:

	Thickness of beds. Feet.	Inches.
1. Bands of ironstone and crystals of selenite enclosed in shale, with a thin, imperfect seam of coal,	(?)	
2. Light-gray and yellow sandstone, containing *Stigmaria*,	6	
3. Shale,	2½ to 3	
4. Coal,	1	6
5. Fire-clay, containing Stigmaria; together with slaty clays, containing argillaceous oxide of iron,	45	6

Half to three-quarters of a mile higher up stream, the bed of sandstone, which lies fifty feet above the river in the last section, is already within twelve feet of the water-level. Here the eighteen-inch seam of coal can be seen underlying it, reposing on fire-clay containing *Stigmaria*. The argillaceous shale over the sandstone contains much argillaceous oxide of iron, and includes one band of ironstone, four to six inches in thickness, lying about five feet above the bed of laminated sandstone.

Two to three miles above this, in a ravine, about a quarter or half a mile from the Slue, there is a wall of bituminous shale, lying in large, thinly-laminated sheets.

Near Bennington, the bluffs consist chiefly of soft, light-buff sandstones, which were penetrated twenty-two feet in digging a well; and a little above that place a three-foot seam of coal is seen near high-water mark. Coal has also been found in the bluffs opposite Bennington, which is preferred for blacksmiths' use to the bed immediately on the river. At the foot of the bluffs, below the site of Perryville, sandstone extends down to the water-level. This sandstone rises, up stream, and discloses five feet of shale beneath it. A band of carbonate of iron, and a calcareous rock resembling hydraulic limestone, are associated with this shale, and beneath the whole lies an eighteen-inch seam of coal, resting on marly clay. The

rocks have an undulating dip, so that the bed of coal and underlying clay are brought to the surface, and as often again depressed beneath the water-level.

On the southeast quarter of Section 8, Township 77 north, Range 21 west, a brown, ferruginous sandstone lies fifty feet above the river. A portion of this rock is a complete agglutination of vegetable remains, partly converted into hydrated brown oxide of iron, and partly carbonized. A quarter to half a mile higher up, ledges of sandstone, presenting cross-lines of deposition, and oblique ferruginous veins, extend down to the water-level. Not far from Dam No. 26, and near the line between Sections 10 and 11, Township 77 north, Range 22 west, there are probably one or more beds of coal, but the sliding of the shales hides the greater part of Section No. 38, D. Within three or four feet of the top of the shale, i. e., at a height of forty to forty-five feet from the river, there is at this locality a band of ironstone,* having a specific gravity of 3·45, associated with some sulphuret of zinc, the joints being coated with a crust of silicate of alumina.

It appears from the above analysis that this ironstone is very analogous in its composition to the ore known in Scotland as "Mushet's Black Band;" the chief difference being a smaller percentage of carbonaceous matter, and the substitution of phosphorus for sulphur.

It is more than probable that a repetition of the analysis of the "Scotch Black Band" would give also a small percentage of phosphorus; since I only succeeded in detecting and estimating this element in the Des Moines ore, by methods which have been introduced into analytical chemistry within the last few years.

* An analysis of the ironstone by the humid method gave as follows:

Bituminous or carbonaceous matter,	01·0
Insoluble earthy matter,	07·6
Carbonate of the protoxide of iron,	65·0
Carbonate of lime,	07·2
Carbonate of magnesia,	10·0
Alumina,	01·8
Peroxide of iron,	04·8
Phosphate of iron,	02·6
	100·0

After pounding and sifting the raw ore, a quantity weighing	1225	grains
was roasted, and exposed to a red heat in a shallow vessel; after roasting, it weighed	865	"
Loss by roasting,	360	"

Being equal to 29·4 per cent.

The colour, after roasting, was a purple-brown: an assay was then made in a black-lead crucible, at a high temperature, with the following ingredients, in the proportion of

	Grains.
Roasted ore,	865
Bottle glass,	865
Chalk,	865
Charcoal,	134

There resulted therefrom a button of light-gray iron, weighing 377 grains; equal to 43·5 per cent. of the roasted ore, and 31 per cent. of the raw ore, differing only 2·5 per cent. from the percentage of metallic iron by the humid method.

The existence of phosphorus in this ore is not a matter of merely scientific interest, but of practical importance also. Collier and Rinman assert, that the "cold-short" property of iron (that is, its liability to become brittle when cold), is due to the presence of the phosphoret; while Mushet, whose knowledge of iron and its properties is probably superior to that of any other writer, doubts the assertion. It has, he says, been matter of common remark, that iron of the most perfect quality, as the Swedish, gives out, in working, a strong phosphoric smell. And he adds, that any iron can be made cold-short, by introducing into the blast furnace, through the medium of the flux or otherwise, silica in excess.

In support of this view, he remarks, in his work on iron and steel: "The flue cinder of the balling furnace, which, on an average, contains thirty per cent. of silica, and the flue furnace cinder of the puddling furnace, containing forty per cent., while sand bottoms were in use, furnished striking illustrations of that fact. At first, when these cinders, containing from forty to fifty-two per cent. of iron, were returned to be smelted for the production of forge pigs, the brittleness of the iron was so much increased, that fears were entertained as to the practicability of their use, and maintaining a marketable quality of iron. The change of system which took place from puddling on sand to puddling on iron bottoms, by introducing a less quantity of silica into the blast furnace, had a great tendency to reduce this evil, and restore fibre to the bar-iron."

And he concludes by saying: "From this fact being so clearly ascertained, we obtain a clue to explain the probable cause of cold-short in iron generally, by attributing it to a predominant quantity of silica in the ore, rather than to the existence of phosphorus."

Here is a marked difference between the opinion of so experienced a man as Mushet, and the statement of Rinman, made, in the summer of 1849, to the British Association, at their annual meeting; the statement, namely, that, in every instance in which Swedish iron has proved cold-short, he had been able to detect the presence of phosphorus.

To this important subject I invite the attention of American chemists and iron-masters. It is only by careful chemical analysis, conducted after the most approved method, that this moot point can be finally determined. Should phosphorus invariably be found in cold-short iron, while it should prove to be uniformly absent in iron free from that defect, the inference will be a fair one, that phosphorus is the producing cause.

Although phosphorus has been detected, as I have shown, in these Des Moines ironstones, yet, as they have not yet been worked, no practicable inference, in connexion with the present inquiry, can thence be drawn.*

Many of the carbonated ironstones observed at the various localities on the Des Moines, both above and below its forks, have much the same external appearance as the specimen here analyzed, and will probably yield by analysis similar results, being essentially carbonates of the protoxide of iron, composed of

* The amount of phosphorus seems to vary much in different specimens. One procured below Lafayette, near Dam No. 26, on the Des Moines, yielded, by analysis, the sixteenth of a per cent. only.

One atom of carbonic acid,
One atom of protoxide of iron.

The analysis given by Dr. Thomson in his "System of Chemistry and Mineralogy," vol. i. p. 446, of the light grayish black variety of "Scotch cross-basket ore," as determined by Dr. Colquhoun, is still more closely allied to these Des Moines ores; both containing very nearly the same amount of carbonic acid, and protoxide of iron, and differing only in the Iowa ore, containing three per cent. more of peroxide of iron, one per cent. less carbonaceous matter, and two per cent. less of earthy matter; consequently it has a rather higher specific gravity than the Scotch ore.

The composition of the "Cairnhill Black Band," analyzed by Dr. Colquhoun, gives within a fraction of one per cent. the same amount of protoxide of iron, but less carbonate of lime and magnesia, and more carbonaceous and earthy matter. This is the measure connected with the Ell-coal, and was the first of this species of ore discovered and wrought. The percentage indicated by Dr. Colquhoun as the average yield of the "Cairnhill Black Band," corresponds exactly with the percentage of iron (33 per cent.), obtained from my analysis, in the humid way, of the Des Moines ore. The large amount of carbonaceous matter in the Cairnhill ore (17 per cent.), indicates that the Iowa ore would require a larger amount of carbon for its reduction than the Scotch ore. If the former ever should be wrought for iron, as it doubtless will, when the country becomes more densely populated, it will be interesting to see whether the iron produced on the large scale has cold-short properties, in accordance with the views advanced by Mr. Rinman at the meeting of the British Association at Birmingham.

Coal has been found at various places in the vicinity of Dudley, as well as on Middle River and its branches. The carboniferous rocks above Dudley are covered, however, by a considerable thickness of marly earth, perhaps of the age of the *Loess* of Germany, resting on ferruginous conglomerate, a section of which, eighty feet high, presents itself on the Des Moines, on Section 23 (?), Township 78 north, Range 23 west.

On Section 15, same township and range, a bed of coal lies twelve to fifteen feet above the water, enclosed between beds of shale, the whole overlaid and partly concealed by the drift. A bed of corresponding thickness is also seen on the right bank of the Des Moines, half a mile below the Forks, on Section 11 (?), Township 78 north, Range 24 west.

Carboniferous Rocks of the Des Moines, above the Raccoon Fork.—On Section 4, Township 78 north, Range 24 west, is a seam of coal, known as Hall's Coal-bank. It is between two and three feet in thickness, over and underlaid by argillaceous shale, the whole being covered by soft sandstone, schistose below, and thicker-bedded above. (See Section No. 40, D.) The upper part of the coal is impregnated with iron pyrites; the lower part is of better quality.

From the argillaceous layers there oozes a mineral water, having a faint brown tinge, acid reaction, and strong styptic taste. This water gives with ammonia a

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white and rather gelatinous precipitate, having a slight tinge of green; with caustic potash, a copious white, gelatinous precipitate, partly soluble in excess; the alkaline solution, after filtration and saturation with hydrochloric acid, gives a precipitate by supersaturation with ammonia. Hydrosulphuret of ammonia produces a copious black and white precipitate, each remaining distinct if the liquid be not shaken. With carbonate of ammonia, a copious white precipitate; with ferrocyanide of potassium, a light blue precipitate; with oxalate of ammonia, little or no precipitate; with chloride of barium, a copious white precipitate, insoluble in nitric acid; with nitrate of silver, a slight white precipitate, increasing by standing, and darkening in the rays of the sun; with chloride of platinum, a slight yellow precipitate. These reactions with chemical reagents show that it is an acid solution of sulphate of alumina, sulphate of potash, sulphate of protoxide of iron, and a little chloride of potassium and sodium. It is, in fact, a double alum of potash and protoxide of iron. The same kind of water was observed at several other localities on the Upper Des Moines.

About two miles above the Forks, on the left bank, two beds of coal are seen; the main one lies about twenty feet above the water-level; the other bed, which is only four to six inches thick, lies above, and is separated from the former by about one foot of shale. Seams of a grayish clay run vertically and diagonally through the principal coal-bed.

About one mile higher, on the same side, a thin bed of coal is exposed, near the water-level, associated with argillaceous and ferruginous shale, depositing in their course a gelatinous, hydrated oxide of iron.

At several points between the last-mentioned localities and Hunt's Bend, designated on the chart of the river, a gray limestone occurs, a few feet above the water-level. By exposure, this calcareous rock turns brown, no doubt from the peroxidation of the iron. It is charged with *Productus Flemingii; Cardina nana* also occurs in it. Both above and below it are argillaceous shales, as seen on Section No. 42, D. The upper shale includes nodules of ironstone, and septaria, veined with red calcareous spar. Towards the summits of the ridges near by, under the drift, there is a white limestone; at a lower level, soft sandstone, like that at the Forks, and still lower, a bed of coal. The relative thickness of this bed, and the exact order of superposition, cannot be satisfactorily seen. Some of the darker limestone will probably answer for making an hydraulic limestone.

On Section 10, Township 80 north, Range 25 west, are alternations of red, purple, and gray shales, as shown on Section No. 48, D. The red and purple shales have somewhat the appearance of red pipe-stone, but are much softer, and subject to disintegration; they leave a pale red streak, approaching in character to the soft red, argillaceous ochres, known to carpenters under the name of "keel." Three to four miles higher up, is another bank of the same character. (See Section 49, D.)

On Section 14, Township 81 north, Range 25 west, a gray productal limestone is elevated thirty-five feet above the water-level, with a bed of shale and coal beneath it, as seen on Section 44, D. In the shale, some crystallizations of selenite were collected. The shale between that and the productal limestone includes septaria and calcareous blocks that may afford hydraulic cement.

On Section 16, same township and range, we discovered, at an elevation of eighteen feet above the water-level, a band of translucent calcareous spar, having the prismatic structure of arragonite; the fibrous prisms collected, however, into perfect conical bundles, with the apex of the cone turned either directly downwards, or sometimes upwards, the external surface of the cones crimped, possessing, in fact, at the same time, the most perfect *tutenmergel* structure, as if produced by some combined process of stalactitic infiltration and simultaneous crystallization. The calcareous *tutenmergel* band is one and a half to two inches in thickness, thinning out, and slightly dipping towards the east. It is enclosed in dark argillaceous shale, with some layers of finely laminated carbonaceous limestone, charged with the spines and fragments of *Productus Flemingii* (?), and containing, amongst other fossils, a beautiful, delicate, small species of *Chonetes*, allied to *C. variolata*, but distinguishable from it, in being ornamented by a greater number of ribs, and given in the Appendix under the name of *Chonetes semiovalis*. In the shales, over the *tutenmergel* bed, is an imperfect seam of coal; the whole being crowned with sandstones, which are laminated where they rest on the shale, but pass afterwards into thicker layers. (See Sections No. 51 and 52, D.) At this locality, as well as at several other points, both above and below the productal limestone, the septaria and calcareous blocks embedded in the shale have the external aspect of hydraulic cement.

A mile and a half above this, the brown productal limestone lies within two feet of the water, associated with gray clay, and covered with drift.

About two miles above our encampment of 31st August, and four to five miles above the Rapids, three beds of coal are exposed, but they are all of an inferior, slaty character, much impregnated with sulphuret of iron. The lowest lies at an elevation of eight feet above the water-level, and is three inches thick; the middle bed is twenty-five feet up the bank, and varies from two to three feet in thickness; the upper bed is thirty-eight feet above the water-level, and is about two feet thick, intersected with a band of sulphuret of iron. Argillaceous and shaly beds, including septaria and ironstones, constitute the intervening strata; at the upper end of the exposure, laminated sandstones overlie the whole, as shown in Section 59, D. Some layers, both in the lower and upper part of the exposure possess the *tutenmergel* structure. The ironstone is not very pure, nor in great abundance; some sulphuret of zinc is disseminated with the iron. The position of the selenite at this locality shows its origin; agglutinated crystallizations are seen shooting forth from calcareous masses charged with the sulphuret of iron. After the iron and sulphur have undergone oxidation, and are converted into the sulphate of the protoxide of iron, a mutual double decomposition is effected between that salt and the carbonate of lime, by which there result sulphate of lime, and either carbonate of the protoxide of iron, or, if a further oxidation of the iron ensues, a hydrated peroxide of iron, the carbonic acid being set free. Much of the ironstone disseminated in the shales of the Des Moines, doubtless owe their origin to this kind of chemical reaction. The whole strata have a waved dip to the northwest, and some of the subordinate layers gradually thin out, and become blended with the enclosing matrix. This kind of

wedge-shaped interpolation is well seen at the next section, a little higher up on the Des Moines, above Bald Point, where two thin seams of coal are seen tapering away until they finally run out as they approach each other. (See Section No. 60, D.)

MARL AND DRIFT RESTING ON CARBONIFEROUS STRATA, DES MOINES.

At a westerly bend of the Des Moines, here represented, designated on the chart of the river, "Bald Point," the hills are about two hundred feet high; laminated sandstone forms their base, while the main body of the hill is composed of ash-coloured, marly earth and drift. One mile above Bald Point, ledges of reddish limestone extend to the height of five or six feet above the water-level; and half a mile further, or about eight miles above the Rapids, fragments of ironstone are scattered on the shore near the water-level, mixed with a conglomerate of gravel and sand, cemented by oxide of iron. A few hundred yards above this place, on the left bank of the Des Moines, below the mouth of Honey Creek, ledges of soft sandstones project from under the drift. Interposed between the beds is a wedge-shaped siliceo-calcareous rock, which projects beyond the sandstones.

The blacksmiths of Boone County have obtained some coal from a bed situated on Section 5, Township 83 north, Range 26 west. From one to two miles above the line between Townships 83 and 84, in latitude 42° 2′, alternating beds of sandstone occur, overlying shale and coal; and two to three miles higher two seams of coal are seen above the water, one eighteen inches, and the other ten inches thick. They are associated with shales, and shaly sandstones. Nodules of ironstone are disseminated in the argillaceous beds below the eighteen-inch seam of coal. The lowest bed, which decomposes into a fine, light-coloured potters' clay, gives out, when applied to the tongue, a strong astringent taste.

About three hundred yards up the river, in nearly a northerly course, the lower bed of coal is at the water-level, but rises again, in conformity to the undulating depressions and elevations of the strata prevalent through this region. The beds of coal thus attain an elevation of twenty to twenty-five feet above the water-

level, near our encampment of the 9th of September, as designated on the Chart. Not far from this place we encountered two granite boulders, the first large erratics we observed in our ascent of the Des Moines. A chalybeate spring issues from under the coal-banks.

A short distance from this section, ridges one hundred to two hundred feet high, composed chiefly of sand, gravel, and drift deposits set in, concealing the carboniferous stata, so that they only appear at long intervals. It was not until after passing the Boone Fork, that an opportunity was offered of again inspecting the rocks.

A short distance above the mouth of Brushy Creek, micaceous sandstones, of the coal formation, are exposed, at an elevation of from fifteen to twenty feet; and two miles further, on the right bank, a bluish gray clay is seen near the water's edge, charged with fragments of argillaceous iron ore, together with an impure gray calcareous rock, and loose pieces of soft sandstone; but the exact order of superposition cannot be seen, by reason of the thick vegetation and deep alluvion.

Five miles above Brushy Creek, argillaceous shale, with nodules of ironstone, is overlaid by slaty sandstone, which latter is about fifteen feet above the water-level. (See Section No. 61, D.) About a quarter of a mile beyond, hard, black, bituminous shale, splitting into sheets, rises from beneath the water-level, and soon attains an elevation of from fifteen to twenty feet, covered by erratic deposits, which continue to accumulate in proceeding towards the north. The shales enclose large angular masses of compact black calcareous rock, which may answer for an hydraulic cement.

About half to three-quarters of a mile above this locality, a conspicuous boulder of porphyritic granite lies in the river, near the left bank. Ten miles above the Boone Fork of the Des Moines, solid ledges of sandstone, containing vegetable impressions, and embracing some thin, interpolated layers of conglomerate, present themselves to view. These sandstones gradually increase in thickness on approaching the great easterly bend of the "Burnt Woods District," where the current of the Des Moines strikes mural escarpments of thirty to fifty feet on alternate sides, as it is deflected from one high point of land to another. Twenty to twenty-five miles above the Boone Fork, they even attain the height of one hundred and ten feet. (See Section No. 62, D.)

Near the termination of these bluffs, just below our encampment of the 5th September, in sight of the Burnt Woods, there is a good deal of hydrated oxide of iron, but rather too much impregnated with sandy particles to be of practical value. The sandstones, with some shaly intermixtures, continue within sight of Lott's Rapids, about five miles below the point where the north and south line, between Ranges 28 and 29, crosses the Des Moines. Here, limestones can be seen at a low stage of water, covered with a multitude of boulders, which fill the channel; and these so obstruct the navigation, that it was with difficulty we succeeded in floating the bark canoe containing our provisions and camp equipage, over the shoals, although the river was high.

It seems as if an accumulation of drift had taken place, from some local cause, such, perhaps, as the stranding of an iceberg loaded with erratics; since above and

below the rapids, boulders are much less abundant than they are immediately on them.

About a quarter of a mile above the Rapids, sandstones again appear in place beneath the drift. Five miles higher up, and two to three miles below the Second Correction Line, the shaly beds extend to the height of sixty-five feet above the water-level, where they are overlaid by from twenty to thirty feet of heavy beds of white and light-gray gypsum rocks, lying in horizontal, conformable beds, which, at a little distance, might be taken for ledges of white sandstone. For thickness and extent, this is by far the most important bed of plaster-stone known west of the Appalachian Chain, if not in the United States. It is seen at intervals for three miles, exposed on both sides of the Des Moines, in mural faces of from eighteen to twenty-five feet, always overlying pink shales, from beneath which copious springs of excellent water issue. It has been traced in the ravines, back from the river, for nearly three-quarters of a mile, where it is finally lost under the deep alluvion of the vast plains that stretch away to the west. There is every reason to believe that it occupies an area of from two to three miles square, retaining an average thickness of twenty feet; perhaps double that thickness at certain points. This plaster-stone of the Des Moines does not appear to have been deposited in nests or conical heaps, as in the shales of the Onondaga Salt Group of New York, but rather in continuous horizontal beds, conformable to the underlying shale. The immense quantity of gypsum of this part of the Upper Des Moines, can hardly be accounted for on the principle of a double chemical decomposition, between sulphate of iron and carbonate of lime, formerly existing where the plaster now is, since there does not appear to be an equivalent bed of iron in the vicinity, nor yet beds of limestone, except thin bands of black, bituminous, calcareous rock, by no means extensive, that are in immediate connexion with the plaster-beds. It seems rather to have been an original deposit at the bottom of the ocean; the sulphate of lime having probably been derived, during the formation of the rocks, from submarine sources.

In mass, the plaster-stone* is white, with light shades of a yellowish gray colour, running in horizontal streaks; in powder, it is as white as flour. The texture is fibrous; the horizontal face presents a stratified appearance. When ground or burnt it sets well, becoming hard in the course of a few minutes.

Everywhere in the region of the plaster-stone, the banks of the Des Moines are clothed with an extraordinarily thick vegetation; indeed, the undergrowth and vines

* Its composition is—

Sulphate of lime,	70·8
Lime combined with silica (?), as silicate of lime,	2·2
Carbonate of lime,	2·
Phosphate of lime,	1·1
Insoluble matter,	2·
Magnesia,	0·7
Water,	20·
Chloride and sulphate of alkali,	·3
	99·6

are so densely interlaced, that it is penetrated only with great labour. The dark shales in the lower part of Section No. 63, D, contain some imperfect seams of coal, or rather, what might almost be termed mineral charcoal, since it presents the woody, fibrous appearance of absolute charcoal.

After leaving the river bottom, the land rises in two beautiful terraces, the one a hundred feet above the water-level, the other fifteen to twenty feet higher. The first terrace is beautifully interspersed with groves, presenting delightful sites for farms. The soil of both is exceedingly rich; that of the first terrace is the warmest, advancing vegetation with greater rapidity than the upland terrace. The latter, however, is more durable, and contains so large a percentage of organic matter, that when wet it is almost black.

Below the Lizard Fork, at several places, shaly beds are exposed, including a seam of coal four to six inches in thickness. At one point, the bed of coal lies fifteen feet above the water-level, with a northerly dip, which brings it within ten feet of the river in the distance of a few hundred yards. The *tutenmergel* structure is observable in some of these argillaceous beds; and in the same vicinity are black calcareous layers, like those observed above Brushy Creek. Low, broken ledges of white calcareous rocks rise from beneath the shaly beds at the mouth of the Lizard Fork, as seen on the right of the subjoined wood-cut. These beds are

CARBONIFEROUS LIMESTONE, LIZARD FORK, DES MOINES.

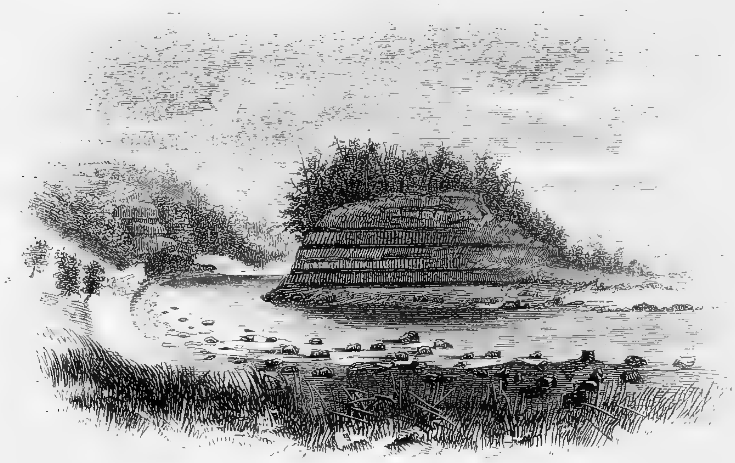
also seen at intervals for five or six miles. One hundred yards above the Lizard Fork, on the main stream, the position of this limestone is well seen, where it forms a distinct arch under the shale.

Two miles above the Lizard Fork, this limestone forms a solid wall, twelve to fifteen feet thick, the beds being much broken.

At the Great Slide (Section No. 65), five or six miles above the Lizard Fork, in latitude 42° 33′, two imperfect seams of coal lie fifteen to twenty feet apart, above and below beds of ferruginous sandstones, and underlaid by a great mass of shaly beds, that by exposure crumble and give way, producing extensive depressions, and great

slides. These, perhaps, conceal a third bed of coal, corresponding to that seen near the Lizard Fork. The shale contains many small crystals of selenite, but no beds of plaster-stone can be seen overlying the shales. Ferruginous alum-waters ooze from the bank, like that tested above the Raccoon Fork.

A corresponding section of shaly beds and coal presents itself to view at a westerly bend of the river, in sight of the "Great Slide," as exhibited in the annexed vignette. This is the last out crop of coal-measures which we witnessed on the Des Moines River.



LAST EXPOSURE OF COAL, UPPER DES MOINES.

Beyond this, the stream enters and meanders through an open prairie country, presenting to view low drift knolls, similar to those represented, high up on the Iowa, on the illustration page. The bed of the Des Moines soon becomes contracted to about fifty yards, and canoe navigation is rendered difficult by shallow rapids, over pavements of boulders.

Having arrived at that part of the Des Moines, beyond which there was little prospect of tracing much further the carboniferous rocks, as I judged, both from the aspect of the country and the representation of hunters; finding also that our store of provisions was almost exhausted; that I was myself in a disabled condition, from a gun-shot wound received in the arm, as stated in the Introduction; that my men were exhausted by fatigue and exposure, so that all but one had contracted intermittent fever; I decided upon returning to Fort Des Moines.

In reviewing the general features of the carboniferous rocks of the Des Moines, as indicated by local sections, it appears, that without taking into account the numerous smaller disturbances, there are three principal axes of depression; one at Raven Cliff, one at Elk Bluff and Red Rock, and one below the Burnt Woods, near the great bend of the Des Moines, a few miles south of the Second Correction Line; while the chief axes of upheaval are about St. Francisville, Sweet Home, Bentonsport, and Dam No. 15, above Ottumwa, where the underlying limestones attain their greatest thickness. It must be remarked, however, that the elevation of these rocks above the water-courses is in a great measure due to the scooping out

of the country towards the great central valley, and to the excavation of the Des Moines. This river falls one hundred and eighty-three feet in its descent from the Raccoon Fork to the Mississippi, a distance of two hundred and four miles by the meanders of the river, and one hundred and twenty miles in a direct line.

It becomes a question, too, whether the carboniferous rocks of the Des Moines, are not the attenuated margin of the great Illinois coal-field, with which it was at one time connected; and, if so, whether all the strata above the Archimedes limestone of St. Francisville, represent only the Yoredale rocks and Millstone Grit of Great Britain, and not the coal-measures proper.

After replenishing our stores at Fort Des Moines, and allowing my voyageurs to recruit somewhat from their fatigues and sickness, I commenced an examination of the Raccoon Branch of the Des Moines. From the low stage of the water, we were not able to ascend it beyond the first "Main Fork," a distance of forty-five miles. The exposures of rock are not so frequent as on the main branch.

At the first high ground on the right bank, a seam of coal has been exposed, in digging a foundation for a mill, about fifteen feet above the river. Six inches of the coal is exposed, covered with ferruginous clay and soil. This coal is probably not in its original position, but has slid from above. A little higher up, some coal has been dug out, but the crumbling argillaceous debris prevented an examination.

Four miles by the meanders of the river, and about one mile and a half in a direct line from the mouth, a disintegrated bed of clay, including some imperfect coal, lies at an elevation of forty-five feet. There seems to be another bed of coal at a lower level, fifteen to twenty feet above the bed of the river; but the excavations at this place have not extended deep enough to uncover it.

At the rapids, fourteen miles above the mouth, there is limestone in the bed of the river, overlaid by sandstone. In a ravine near by, shale and dark schistose limestone are partially exposed. The limestone contains *Productus cora.*

Ten or twelve feet above the base of a bluff, on the left bank, at a bend two or three miles higher, shaly layers are associated with an impure calcareous rock.

In a long bend of the Raccoon Fork, twenty-eight miles from its mouth, a brownish gray limestone was observed, charged with *Productus Flemingii,* minute Entrochites, and an *Orbicula,* allied to *O. Davreuxiana* (De Konninck); also, a small, undetermined species of *Terebratula.* This limestone seems to correspond to the productal limestone found on the Main Fork, near Keeth's Rapids.

The best section which I saw on the Raccoon River, was eight or ten miles below the First Forks. Forty feet of strata are exposed by a slide, in the following order from above downwards:

	Feet.
Shale,	2
Siliceo-calcareous rock,	2 to 2½
Shale,	1
Band of bituminous limestone, and septaria,	(?)
Shale, with some imperfect coal and gray indurated clay,	15
Red ferruginous argillaceous bed,	3 to 5
Hidden in the slope,	15

From half a mile to one mile higher, sandstones overlie the shaly, indurated argillaceous beds, thus:

Sandstone,
Argillaceous shale,
Shaly sandstone.

Here vertical seams of indurated clay traverse the shaly sandstones, much in the same manner as on the Cut-Off of the Wabash River, in Posey County, Indiana.

At Elbow Rapids, two or three miles further up, beds of ripple-marked sandstone lie two feet above the river-level, underlaid by laminated sandstone, and covered by shaly rock, and beds of brown limestone, containing the pygidium of *Griffithides*. At the base of a ridge near the mouth of Moore's Branch, is an outcrop of sandstone, and an impure limestone; in the former, some imperfect fluted impressions were found, analogous to those which characterize the *Sigillaria*, and about one mile below the First Forks, impure gray limestone, sandstone, shale, and shaly sandstones, protrude beneath the drift. These constitute the only exposures of rock witnessed on this branch of the Des Moines, and although partial, they are yet sufficient to show the extension of the carboniferous rocks westwardly beyond the Raccoon Fork of the Des Moines.

On our return to Fort Des Moines, I sent the canoe and men down the river with the collection, while I crossed the interior of Iowa, by way of Middle River and Pisgah, to Council Bluffs, on the Missouri River, with a view to trace the extension of the carboniferous rocks further westward, through the interior of Iowa.

From the nature of the country, this became a difficult task. In the northern part of Iowa, deep alluvial and drift deposits so effectually conceal the rocks, except in the immediate cuts of the main streams, that I only succeeded in obtaining the desired information at a few points on the principal water-courses.

Below the crossing of North River, ten miles west of Fort Des Moines, at a settlement known as Linn Grove, dark, schistose, productal limestone was found, along with a hard, brittle, ponderous, ferruginous limestone, which seems to originate in shaly beds, only very partially exposed in a cut for a mill site. This limestone has been used by the neighbouring settlers in the construction of fire-places. It is said that, at a low stage of water, an imperfect seam of coal can be seen below the ford; and the blacksmith of the settlement has obtained coal in small quantities a few miles above the mouth of North River, as well as at Black Oak Grove, between the two forks of Middle River. At the latter place, lime has been burnt for the use of Fort Des Moines.

The nucleus of the more elevated grounds, under the drift on North River, seems to be composed of soft freestones, which have been employed, along with the ferruginous limestone, in building chimneys. On the west side of Middle River, loose slabs of reddish-buff limestone lie strewn on the slope of a hill; but no section is exposed by which to determine its proper relative position.

In the bed of a branch which flows into the Clanton Fork of Middle River, light-gray limestone is in place, containing *Fusulina cylindrica*, *Chonetes variolata*, and

Favosites scabra. Here also are loose sheets of shale, which have been washed from the banks of the creek, and lie mixed with small boulders over the limestone. A bed of coal a foot in thickness has been discovered in this neighbourhood.

On Grand River, in the vicinity of Pisgah, nothing but drift is to be seen. Some miles down the stream, however, near a mill-site, I was told by the Mormons that a kind of "soapstone" could be seen at a low stage of water, which I suppose to be an indurated argillaceous shale; these deposits being popularly known by that name in the West. This I was unable to examine in person: indisposition, from fatigue and exposure, having brought on a relapse of intermittent fever, contracted while exploring the Des Moines.

The distances from Fort Des Moines to Pisgah are as follows:

	Miles.
To the crossing of North River,	10
To Middle River,	12
To the South or Clanton Fork of Middle River,	2
To Clanton's,	2
To Big Hollow,	14
To Forks of road leading to Bellevue,	4
To Pisgah,	6
Total distance,	50

On the route from Pisgah to Council Bluffs, I crossed Grand River, the Platte Branch of Grand River, two branches of the Nodoway, A Hundred and Two River, and the east, middle, and west branches of the Nishnabotna River. It was only on this latter stream that any rocks were found in place.

On the East Fork of the Nishnabotna, the following section was observed:

1. Soft, brown sandstone, at an elevation of fifty feet.

2. A light-buff limestone, containing *Fusulina cylindrica, Bellerophon,* allied to *B. Urii,* an undetermined species of *Cypricardia* and *Gervillia,* at an elevation of twenty-five feet.

3. Limestone of irregular fracture, containing few or no fossils under the Fusulina limestone.

4. Compact limestone, one stratum of which is mottled with brown, in the bed of the river.*

A lighter-coloured gritstone is found in a grove, one mile east of the same stream. On the main branch of the Nishnabotna, a close-textured, gray limestone occurs, like that on the East Fork, containing casts of *Bellerophon Urii.*

After crossing the Nishnabotna, no rocks appear in place until reaching the Missouri River. A change can be perceived, however, in the character of the soil, which becomes more argillaceous than it is between the forks of Grand River and the branches of the Nodoway River. In dry weather, the roads, except in the low places, become nearly as hard as if paved with rocks, and the wheel-tracks look as smooth as if polished.

* The intervening spaces between these beds are hidden from view.

On approaching the Missouri, the hills bordering its extensive bottoms, known as Council Bluffs, attract particular attention, not only from their contour, but from their geological formation. Where vegetation has been removed from their slopes, they are seen to be composed chiefly of a fine, ash-coloured, siliceous marl, or loam, effervescing with acids. In favourable situations, many species of terrestrial and fluviatile shells were discovered, of the same species as are found in similar deposits in the Wabash Valley, which are considered contemporaneous with the Loess of the Rhine.

The most abundant species are, *Helix thyroideus, H. alternata, H. monodon, Helicina occulina, Succinea campestris* (?), and *Pupa armifera.* The base of the hills under this marl is gravel and drift; the whole resting on carboniferous strata, which show themselves at intervals near the bed of the Missouri, and in a few places at the base of the bluffs.

The bottoms of the Missouri at Council Bluffs vary from eight to twelve, or even fifteen miles in width. Towards the narrows of the Nishnabotna, these bluffs contract in width, until, below the mouth of Nodoway River, they are only two or three miles apart. The highlands throughout this distance present great uniformity of outline, appearance, and composition, proving that within these limits, embracing

HILLS OF SILICEOUS MARL, COUNCIL BLUFFS.

nearly two degrees of latitude, the waters of the Missouri, many hundred miles from their embouchure, have been pent up into vast lake-like expansions, at the bottom

of which a fine lacustrine sediment collected, subsequent to the drift period; entombing not only fresh-water species of mollusca, but a still greater number of terrestrial *Helicidæ*, which frequented its shores. These deposits were, at a later period, scooped out during the drainage of the country, which took place in proportion to the gradual rise of the land, and left conspicuous monuments of its existence in the form of abrupt bluffs, one hundred and fifty to two hundred feet above the river bottom. Their appearance is shown by the illustration on the opposite page, sketched in the Missouri bottom, a few miles below Kanesville.

Carboniferous Rocks of the Missouri River.—The first locality where I had an opportunity of inspecting the carboniferous rocks, in place, on the Missouri, was above Bellevue, about twelve or fourteen miles above the mouth of Platte River.

Ledges of light-coloured limestone are exposed here, ten feet above the water-level, on the right bank, containing *Fusulina cylindrica*, *Productus punctatus*, *P. cora*, *P. costatus* (?), *P. Flemingii*, *P. Humboldtii* (?), *Spirifer fasciger* (?), *Orthis umbraculum*, *Terebratula plano-sulcata*, and *Bellerophon*, allied to *B. hiulcus*. (See Section No. 40, M.)

It is said that a seam of coal can be seen beneath these limestones, at extreme low water. Nothing of the kind, however, was visible when I was there, though the water was tolerably low. At the base of the bluff, on the opposite side of the river, limestone has been obtained, some slabs of which contain a few of the same species of *Productus* as at Bellevue. The bluffs rise here to the height of two hundred and thirty to three hundred feet above the water-level.

The next good section is below the mouth of Platte River, and six miles above the mouth of Keg Creek, or Five-Barrel Island, of Nicollet.

Towards the base of this Section (No. 39, M), I found limestone, containing *Fusulina cylindrica*, and above it marly limestones, affording *Productus semireticulatus*, *P. carbonarius* (?), *P. Flemingii* (var. *longi-spinus*), *Orthis umbraculum*, *Spirifer fasciger* (?), *Chonetes semiovalis*, *Allorisma sulcata*, a *Cyathophyllum*, intermediate in its structure between *C. vermiculare* and *C. plicatus*, and a small, undescribed species of *Spirifer*.

A few miles lower down the river, the limestone with *Fusulina cylindrica* is at an elevation of sixty feet (Section 38, M), overlying black, red, and gray argillaceous shales. Hence, it is probable, that the coal reported to have been seen at extreme low water at Bellevue, is bituminous shale, with, perhaps, some imperfect coal; at least, no workable seam was observed at those sections, which present to view the strata inferior to the *Productus* and *Fusulina* bed of Bellevue. The bench of encrinital limestone, which lies about one hundred feet above the water-level, six miles above the mouth of Keg Creek, is only forty feet above the bed of the river, two or three miles lower down; showing that the principal axis of elevation, on this part of the Missouri, is near Keg Point. This is proved also by the northerly dip, at the head of the exposure, and the southerly dip, at the foot.

As the strata again rise, on approaching Fort Kearney, the red, purple, and gray shales increase in thickness (Sections No. 34 and 35, M), and are overlaid by buff encrinital and marly limestones; one bed of the latter is charged with *Productus*

costatus and *P. Flemingii;* another is a complete agglutination of *Fusulina cylindrica,* in a very perfect state of preservation.

The aggregate made up of this highly interesting little foraminiferous shell has so much the appearance of concreted small grain, that some of the inhabitants of the country, to whom I pointed out the rock, could hardly be persuaded that it was not *petrified wheat.*

Up to the time of its discovery, during this survey on the Missouri, I believe it had never been observed in the United States, except in a siliceous stratum near the base of the coal-measures of Ohio; and in Europe, only in the Carboniferous Limestone of Russia.

The same species of *Chonetes* which occurs above the mouth of Keg Creek, is also common at the same locality.

Alternations of regularly bedded limestones and shales can be traced between Fort Kearney and the Nishnabotna for ten miles. In the bluffs skirting the narrows of the Nishnabotna, the purple shales are conspicuous, resting on greenish micaceous sandstones, with vegetable impressions. At the base of the shales, and between them and the sandstones, a bed of dark-coloured limestone is intercalated, containing *Productus semireticulatus,* and, beneath it, bituminous shale and an imperfect seam of coal. The carboniferous strata of the Nishnabotna form the bases of hills varying from two hundred to two hundred and fifty feet in height, presenting an outline similar to those represented on page 132, and composed, in a great measure, of the same fine ash-coloured marl found to prevail at Council Bluffs, and which is doubtless a continuous deposit, above the carboniferous rocks and drift, all along the highlands of this part of the Missouri.

Above Fair Sun Island, micaceous sandstones are seen at the height of from thirty to forty feet, with some calcareous intercalations, underlaid by black bituminous shale and brown encrinital limestone. (Section No. 32, M.)

Just below the mouth of the Little Nemahaw, on the right bank, a section of about thirty feet (No. 31, M) consists chiefly of red schistose sandstone and argillaceous layers, with a band of light gray limestone towards the top, one foot thick, and a dark gray and brownish limestone, containing, in great abundance a small, undescribed *Spirifer,* of the same species as that collected near Keg Creek; also *Orthis crenistria, O. eximia,* and *Chonetes semiovalis.*

In the bend of the Missouri, half a mile lower down, on the same side, heavy beds of pyritiferous, argillaceous shales, and four to five feet of black bituminous shale, are exposed, six feet above the water-level, associated with large slabs of productal limestone, which seem to originate in bands under the shale, in nearly the same succession as shown on Section No. 31, M. No coal shows itself, but there is said to be a bed beneath the water-level, below the Little Nemahaw. The person from whom I derive my information may, however, have mistaken the black shale for coal.

Sixteen miles above the mouth of the Tarkio (at Section No. 30, M), purple and gray shales alternate with limestone. The upper calcareous bed is about two feet thick, and lies at an elevation of twenty-five feet. The bed near the water-level is a light gray and compact productal limestone. Some of the other beds are filled

with a striated and plicated *Orthis*, like *O. eximia.* Near Antelope Island, the strata are much of the same character, except that the limestone is much more ferruginous, and the joints are filled with carbonate of iron.

At the mouth of the Great Nemahaw, soft gritstones present a perpendicular wall of twenty to twenty-five feet to the river. The lower beds are of a greenish hue; the upper, of buff colours. (See Section No. 28, M.) At the base of these hills, a short distance below, are two bands of limestone, with a deposit of argillaceous iron ore between them.

Opposite Iowa Point, in the next bend of the Missouri, a good Section, No. 27, M, is exposed, of fifty feet, consisting of variously tinted argillaceous and bituminous shales, with intervening bands of limestone; the latter being more abundant than in the sections above. A gray layer of limestone, towards the base of the section, yielded *Nautilus tuberculatus, Productus cora, Spirifer fasciger* (?), *Terebratula planosulcata,* and *Orthis umbraculum.*

From a comparison of the various sections obtained between Keg Creek and Iowa Point, it appears that the most inferior of the carboniferous strata of the Missouri are the purple, gray, and black bituminous shales, dark productal limestones, and micaceous green and brown sandstones, which are best displayed in the sections near the narrows of the Nishnabotna, and the confluence of the Great Nemahaw.

Four to five miles below the mouth of Little Tarkio River, the bluffs approach the left bank, and present the first section which I encountered immediately on the river, on that side of the Missouri. It consists of light-coloured limestones, containing but few fossils, and apparently overlying the shales, shown in the Iowa Point Section (No. 27, M), and which are seen at intervals, as far as Elizabethtown and the mouth of Nodoway River, in the form of benches; also as confused heaps and broken slabs lining the shore.

Four to five miles above St. Joseph's, the buff-coloured *Fusulina* bed, similar to that observed near Keg Creek, occurs (Section No. 26, M); its elevation is about sixty feet above the bed of the river, overlying a continuous rugged bench of light-gray, cherty, concretionary limestone. The lower portion of this section consists of alternations of limestone and shales, partially concealed by vegetation, such as have been described as forming the Fort Kearney section. The bench of concretionary limestone is about eight feet thick, and appears in the form of an artificial terrace-wall, traceable for several miles, with a southerly dip; this brings it within fifteen feet of the water-level, twenty miles below St. Joseph's, where it is seen resting on shales. The buff-coloured *Fusulina* bed accompanies it throughout the greater part of this distance. The bluffs at St. Joseph's are composed almost entirely of the same fine, light-yellow, marly loam, that has been spoken of as forming Council Bluffs. In it I found *Helix thyroideus, H. alternata, H. monodon, H. fraterna, Helicina occulina, Pupa armifera* and *Succinea campestris* (?). At this locality, the deposit is at least one hundred and fifty feet thick, and extends almost to the water's edge, resting on gravel; the whole being underlaid by carboniferous argillaceous shales. (Section No. 25, M.)

The evidence of the equivalency of the marly loams of the Missouri and Wabash

Rivers is more unequivocally displayed at St. Joseph's, than at any locality previously examined on the Missouri. The colour of the deposit, its chemical composition, the appearance and state of preservation of the shells, are so perfectly analogous at the two localities, that, placed side by side in a collection, it would be hardly possible to distinguish them. Both have, in all probability, been derived from the destruction of the marly beds of the carboniferous formation.

The barrier which arrested the waters in which this fine loamy sediment was diffused, must have been at the narrows near the mouth of Little Tarkio River; where the distance across from bluff to bluff hardly exceeds two miles.

Coal is reported to have been found some distance west of the Missouri River, opposite St. Joseph's; but as I had no opportunity of visiting the locality, I am not able to vouch for the correctness of the statement. If the report, however, be true, the coal will probably prove to be equivalent to the nine-inch seam, observed by Mr. Jones three or four miles back from the river, between St. Joseph's and Weston.

Near Independence Creek, of Nicollet's map, the strata again rise, so that, below its mouth, the buff *Fusulina* limestone has an elevation of one hundred and fifty feet, resting, as usual, on a bench of cherty limestone, with a rugged surface. There is a second bench of similar limestone in the lower third of the Section; say from thirty to forty feet above the bed of the river. The intervening space is occupied by marls and shales, mostly concealed, and alternating with occasional bands of limestone. Twenty-five feet above the water-level, is a bed of gritstone, lying within a few feet of the lowest bench of limestone. (See Section No. 23, M.)

In the vicinity of Cow Island, and above and below Weston, the benches of limestone can be traced in long ranges of bluffs, first on one side of the river, and then on the other. The principal bench of rugged limestone is usually from twenty to forty feet above the water-level; while, near the margin of the river, a band of compact, hard limestone usually shows itself, which, as it cleaves very readily into regular prismatic blocks, would make an excellent building material. (Section No. 22, M.) At Fort Leavenworth, this bed lies partly under the water, covered with layers of dark bituminous and gray argillaceous shales, over which is a regular wall of limestone, forming a slight anticlinal axis below the Fort. The Fusulina limestone is also here in its usual position. (Section No. 21, M.)

Just below the mouth of Little Platte River, on the left bank of the Missouri River, two principal limestone benches are traceable; the most conspicuous lies thirty feet above the water-level; the other, from thirty to fifty feet higher. (Section No. 20, M.) Towards the top of the exposure, we found five large specimens of *Productus cora* and *P. punctatus;* also *P. costatus* (?), *Spirifer fasciger* (?), and *Terebratula plano-sulcata.* Of these, the *Productus punctatus* is the most abundant. These calcareous beds can be traced, with little variation, as far as the Kansas or Kaw River,* where the bench of rugged limestone comes down to the water-level. The strata again rise, however, so that, three or four miles lower down the stream, near Randolph, its base is from ten to twelve feet above the surface of the water.

* The distance between the Little Platte and Kansas Rivers is represented too short on Nicollet's Map; it is ten miles, either by land or water.

At Wayne City, the landing for Independence, a series of limestone benches, with intervening marlites and shaly beds, extend to the height of two hundred and sixty feet. (Section No. 19, M.) Near the lower bench of limestone, the *Allorisma sulcata* was found, together with a small and probably undescribed species of *Productus.* The highest wall of limestone presents a glistening surface, caused by the reflection of minute facets of calcareous spar disseminated through the rock. The middle beds are more schistose than those either above or below them.

Towards Liberty Landing, the ridges decline to about eighty or one hundred feet in height, where a wall of limestone, six to eight feet thick, is found at an elevation of from thirty to forty feet above the river. Thence the corresponding strata, gradually rising again, appear at Livingston and Sibley, or old Fort Osage, from fifteen to twenty feet higher in the ridges. At the latter point, the base of the section is composed of greenish, concretionary, argillaceous shale, and hard marlite covered by a bed of limestone, eight feet above the water-level, which is partly made up of well-preserved specimens of *Chætetes capillaris.* (Section No. 18, M.) Near the mouth of Fishing River, and above Napoleon, the same fossil is abundant in a gray concretionary limestone, underlaid by sandstone, the position of which is shown on Section No. 17, M. An undescribed species of *Nerita* occurs also at this locality.

The first workable bed of coal which I encountered in my descent of the Missouri River, was at Wellington. It is from twelve to fourteen inches thick, and lies a few feet above the bed of the river, as shown on Section No. 16, M.

At Camden, on the opposite side of the river, nearly east of Wellington, a bed of coal has been exposed, fifteen feet above the river, corresponding probably to the Wellington bed. It is also found at several places on the Snei, south of the Missouri.

The bed of gray limestone, which covers the principal coal-seam at Wellington, containing *Chætetes capillaris,* occupies the same relative position over the coal at Lexington, but here it lies at a greater elevation above the river—fifty feet. (Section No. 15, M.) I was informed by the men working the Lexington coal, that another seam existed in the bed of the river, also overlaid by limestone.

One to two miles below Lexington, the coal and Chætetes limestone are seen on the right bank of the river, forty-five feet above the water-level. The coal is here two feet thick, and rests on indurated slaty clay.

At the bold promontory on the right shore, fourteen miles below Lexington, heavy beds of sandstone, from fifteen to twenty feet in thickness, extend down to the river. Three to four miles further down, at the next promontory, the sandstone is more schistose, and only five feet thick, and rests on four feet of argillaceous shale, seen just above the margin of the river, partly concealed by blocks of limestone which have fallen from above, and which appear to be derived from two calcareous bands over the sandstone. (Section No. 14, M.)

At Waverley, which lies between Mount Hope and the Great Pass, there is said to be coal in the bed of the river; this probably corresponds to the twenty-inch seam at Lexington. Salt has been obtained by the evaporation of springs of brine on the Salt Fork of Rivière la Mine, which heads within a few miles of the same place.

The first bluffs which come up to the Missouri below Waverley are on the right bank, a short distance above the town of Miami, and four to five miles above the mouth of the Wyaconda. They are composed, at their base, of ledges of limestone, twenty feet thick, with nests of chert, the joints of the layers interlocking, like the sutures of the cranium. (Section 13, M.) Some of the layers are filled with disjointed columns of encrinites, many of which are of an elliptical form, and probably belong to a species of *Platycrinus*. Pieces of iron ore, of good quality, were observed at this locality, strewn about the shore; these may originate in a concealed bed of some value.

At Glasgow, on the left bank of the river, the base of the bluff consists of argillaceous shales, with *Septaria*, and schistose sandstone; a thin seam of coal appears about twenty feet above the water-level. (Section 12, M.) Over these, at an elevation of about thirty feet, cherty limestone projects from the bank, in the form of a rough wall. By a southerly dip of the strata, this cherty, rugged limestone is brought within a few feet of the water, at Arrow Rock, presenting a mural face of thirty to forty feet. (Section 11, M.) Near the base of the exposure, a layer of limestone contains numerous remains of encrinites, the whiteness of which contrasts well with the reddish flesh-colour of the matrix in which they are embedded. The same bed contains many individuals of the large variety of *Spirifer striatus*, along with *Productus punctatus*.

Cliffs of the same limestone can be traced below the mouth of Rivière la Mine, and beyond the town of Booneville, forming a series of wave-like, anticlinal axes, of which eight were counted in the distance of one mile. A succession of similar undulating stratifications can be observed at an elevation of from fifty to one hundred feet below Rockport, where they form vertical ledges, from sixty to seventy feet in height. (Section No. 10, M.)

Eight miles below Rockport occurs a bed of light, flesh-coloured, crystalline limestone, charged with *Orthis Michelini*, *Synbathocrinus*, and a fossil shell belonging to the genus *Chonetes*, probably undescribed.

It is between this locality and the mouth of the Osage, on both sides of the Missouri River, that those immense beds of coal are found, which attain a thickness of twenty, perhaps forty feet. This Osage coal* is remarkable, not alone for its extra-

* An analysis of Osage coal by Johnston, resulted thus:—

Moisture, expelled at 230°,	1·67
Other volatile matter,	41·83
Fixed carbon,	51·16
Earthy matter (ashes),	5·34

A trial for sulphur gave 0·483 of that material.

An analysis by the chromate of lead and the chlorate of potash proved the combustible matter to be composed of

		Atoms.
Carbon,	81·855 =	13·642
Hydrogen,	6·168 =	6·168
Oxygen,	11·977 =	1·497

ordinary thickness, but also for the peculiar character and structure of the coal itself, together with the mineral insinuations which invade it.

The lightness of this combustible is such, that before imbibing water, it will float upon that fluid, indicating a specific gravity actually less than 1. In its structure, fracture, and lustre, it has an appearance intermediate between cannel coal and the dull varieties of asphaltum, but it contains 31 per cent. less volatile gases than pure bitumen, and from 5 to 10 per cent. more volatile matter than the ordinary varieties of the bituminous coal of the Western coal-fields.

At the pit west of Marion, this coal assumes a cuboidal, and even a subcolumnar structure, somewhat analogous in miniature to basaltic trap; while, at the same time, a network of pyritiferous ores of zinc and iron have ramified its joints and fissures, and appear often in brilliant crystalline forms,—the whole bearing evidence of great local disturbance, igneous action, and gradual consolidation under heavy pressure. It appears, indeed, altogether probable, from the peculiar character of the coal, its structure, and great local thickness, that it has been subjected to a sufficient degree of heat to have fused or semifused the mass, under a pressure that prevented the escape of the volatile gases, transferring it, at the same time, either in this condition or by sublimation, from its original bed, into some wide, adjacent fissure, formed by disruption of the strata, where it has then very gradually passed into the solid state. Its uniform occurrence in close proximity to an abrupt change in the geological formation of the adjacent country, and the sudden elevation of Protozoic rocks, about to be noticed, together with the highly inclined position of the coal itself, furnishes abundant proof that it has been implicated in the remarkable disturbances which have convulsed the whole of the surrounding country subsequent to the carboniferous era.

On approaching the waters of the Manitou and Bonne Femme Creeks, the limestones of the carboniferous epoch are invaded from beneath by the great uplift of Magnesian Limestones, heretofore noticed as bounding, for some distance on the southeast, the Iowa and Missouri coal-fields, and become, in a measure, confounded with them. This mixed formation composes, in connexion with some intercalations of sandstone, those high mural escarpments in the vicinity of the confluence of the Gasconade and Missouri, and at Tavern Rock; which attain, at the latter locality, where the Meramec approaches within six or seven miles of the Missouri, an elevation of over three hundred feet. (Sections No. 9 to 4, M, inclusive.)

This great axis of Magnesian Limestones separates (by a zone gradually widening as it approaches the Mississippi, to nearly a hundred miles) the outcrops of coal on the Osage, Manitou, and Cedar Rivers, in Cole and Calloway Counties, from the coal-pits opened on the waters of Rivière des Pères, in St. Louis County. Along this portion of the Missouri Valley, it is only on the summits of the highest ridges that any rocks can be found referable to the carboniferous period. Rocks of this age set in again, however, near St. Charles and Manchester. Here the sections are again composed solely of carboniferous limestones; and a section (No. 3, M) obtained near Charbonnière, presented shales and grits surmounted by productal limestone, and underlaid by a five-foot seam of coal, having near its centre, however, a parting of a few inches of argillaceous clay, the whole resting on the St. Louis limestone.

Of similar formation is the country comprised in the neck of land lying between Charbonnière, on the Missouri River, and the Grand Chain, on the Mississippi.

A few unimportant outliers have been detected, on both sides of the Missouri River, beyond the general confines of the Illinois coal-field, in St. Charles and St. Louis Counties, namely, on the ridges giving source to the waters of Coppermine Creek, on the north, and on the south, in the ridges between the Missouri and Meramec.

In no instance have I discovered a workable bed of coal beneath the limestones on which the city of St. Louis stands; although I have been able to inspect the strata underlying that member of the subcarboniferous limestone in more than fifty sections in Iowa and Missouri.

CHAPTER IV.

FORMATIONS OF THE INTERIOR OF WISCONSIN AND MINNESOTA.

SECTION I.

THEIR LITHOLOGICAL CHARACTER.

Extensive deposits of drift prevail throughout the interior of the Chippewa Land District. These fill up the inequalities of the surface, and give, for long distances, a greater degree of flatness and uniformity of contour than one would expect to encounter in a country near the sources of so many large streams.

Between the western tributaries of the Chippewa River and the heads of the eastern branches of the St. Croix and Rum River, this drift seems to rest chiefly on the northern extension of the Lower Protozoic Sandstones of Wisconsin, heretofore treated of in Chapter I.; which formation appears to be invaded only at a few points by intrusive rocks of igneous origin. The drift of this part of Wisconsin, which, in a great measure, conceals these underlying formations, is chiefly of a light, sandy, and gravelly nature; supporting locally, multitudes of boulders, many of which do not appear to be far removed from the parent rock. Where valleys have been excavated by streams, these boulders, undermined and rolling from the higher grounds, have accumulated on the banks and in the beds of the rivers, causing frequent obstructions in the channel, or covering it as with an artificial pavement.

Northeast of the Chippewa, towards the Michigan boundary, the drift reposes chiefly upon Metamorphic Schists and Granitic Rocks; and the same is true of the extreme northern portion of the District, and of a belt of country, some forty or fifty miles in width, ranging north-northeast and south-southwest, from Millelacs, through the Rapids of the Mississippi and St. Peter's Rivers, between longitude 94° and 95°. In these latter regions, besides the coarse boulder drift, sand, and gravel, a deposit of finer materials, more marly and argillaceous, and of an ash-gray colour, prevails over considerable areas.

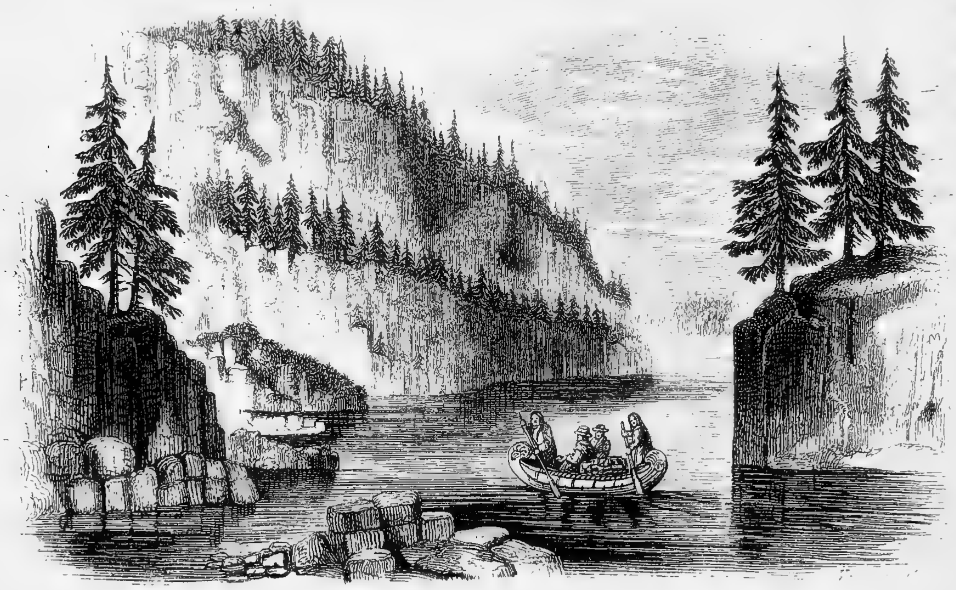
Bordering Lake Superior, red clays and marls, containing a large percentage of oxide of iron, underlie the Boulder Drift.*

Many of the protrusive rocks composing the ranges of the interior of Wisconsin and Minnesota, are referable to some variety of granitic rock, each differing but little from the other in the ultimate elements of their composition; varying, however, considerably, in texture and grain of the component minerals. Some varieties are so fine, and contain so large a proportion of quartz, that they are hardly distinguishable from a quartzite, especially in the more southern ranges. Others have a large proportion of felspar, of fine pink hues.

At a few localities, hornblende enters largely into their composition, and the rocks pass into varieties of syenite or greenstone. This mineral enters also into the composition particularly of the narrow, wall-like dykes, which then assume, for the most part, the close texture and dark aspect of those varieties known under the general terms of Trap and Basalt.

Crystalline schists and metamorphic slates flank the igneous ranges sometimes on both sides, sometimes on the north only. These often include or are in immediate connexion with augitic insinuations, which either appear in dykes, or as bedded trap, conformable to the stratification of the associate sedimentary strata.

The trap of the Dalles of the St. Croix, however, exhibited in the annexed woodcut, abuts immediately against the Lingula beds of the Lower Protozoic Sandstone;



TRAP, DALLES OF THE ST. CROIX.

and broken fragments of these fossiliferous layers are even entangled in crevices and joints of the upheaved mass. The outburst appears to have passed through open fissures, breaking the continuity of strata, without tilting them into inclined planes.

* The reader is referred, for the particulars on these heads, to the Reports of Dr. Norwood and Colonel Whittlesey.

Drift of Wisconsin.—In the preceding pages I have had frequent occasion to mention the position and composition of the drift deposits of the interior. At present only a few general remarks on this subject remain to be made.

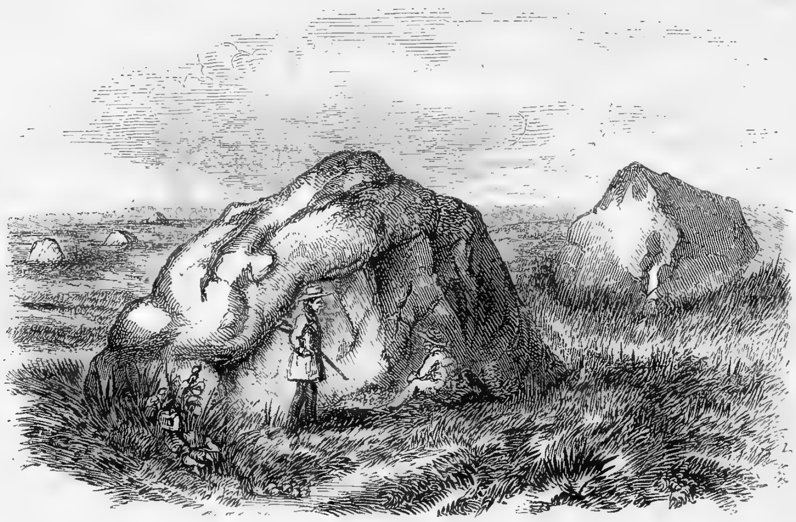
The sand which constitutes the most bulky part of the drift of the interior of Wisconsin, north of the forty-third degree of latitude, has evidently been derived from the denudation of beds pertaining to F. 1. Most of the ground elevated above the swamps and the overflow of the rivers, south of the great water-shed, is composed of this material. Where it rests on the igneous rocks, it supports the pine forests that constitute one of the principal sources of wealth in the Northwest. The trees seem, however, not to attain any great size, except where the siliceous earth is enriched and improved by an admixture of saline matter from some other formation. The source whence these fertilizing elements are derived is usually, if not always, the subordinate hypogene rocks.

Blocks of these rocks, of sizes varying from a few inches to six or eight feet in diameter, form the next most conspicuous materials of the drift. Among these, trappean rocks are much the most common. The position in which they are now most frequently observed is in the bottoms and lining the shores of rivers, lakes, ponds, and swamps. Many of them have no doubt found their way into their present position from more elevated situations, by the undermining and transporting power of water, and perhaps ice. Most of them are confined to belts of country adjoining to rapids where trap rock is either found in place, or where there is reason to believe that it is only hidden by a superficial covering of the detached blocks in question.

They originated at the time of the upheaval of the trap, and at a comparatively recent period. There are facts ascertained which render it probable that a large area of the Northwest Territory has been raised during very modern periods, even since the present Fauna inhabited its rivers and lakes. Below Parkhurst, on the west bank of the Mississippi, I have observed, over a considerable tract, multitudes of Unios, besides a variety of other fresh-water mollusca, of the same species as those now inhabiting the Mississippi and its tributaries, elevated far beyond the reach of the highest freshets; and I am informed that the same deposit can be found in some places, as much as a hundred feet, or more, above high-water mark. It is well known to those who have travelled much in the swampy and undine regions of the Mississippi Valley, that there is a gradual drainage of its waters taking place, even at this time; so that land which was formerly covered with water is now completely dry; and shell marls found through portions of the prairie country show that many of these plains are but drained lakes, or expansions of the great water-courses.

Finally, the fine siliceous and loamy marls, widely distributed in the Valley of the Mississippi, at an elevation of a hundred to two hundred feet above the present rivers, containing *Cyclostoma*, *Physa*, *Succinea*, *Helices*, *Helicina*, and *Planorbis*, with occasionally *Unio*, *Paludina*, and *Melanea*, and considered to be of the age of the Loess of the Rhine, in Germany, afford evidence of a modern rise of the lands of the interior of the Northwest.

Drift of the Prairies of Iowa.—On the west side of the Mississippi, in the vast prairie region of Iowa, the attention of the geologist is frequently arrested by erratic blocks, of enormous dimensions, scattered here and there, and half sunk in the ground. Unlike the boulders we have just been considering, they are far from their original situation. As they rise amid the ocean of grass, they may be seen for miles; and, in the absence of more conspicuous objects, they form the principal landmarks of the traveller. The largest of them might, in an inhabited country, very well be mistaken for cabins, in the distance. The one here represented was



BOULDERS OF PORPHYRITIC GRANITE, IOWA.

measured, and found to be fifty feet in circumference, and twelve feet high. It is probable that at least one-half the rock is buried beneath the ground. Hence may be gathered some idea of their huge dimensions.

These boulders appear to be most abundant along the route which I travelled, between the head waters of the Wapsipinicon and Red Cedar, and some ten to fifteen miles beyond the latter, along a belt which may be twenty to thirty miles in breadth.

Among the smaller of these erratic blocks there is considerable variety; it is, however, somewhat remarkable, that almost every large boulder which I examined in this region is a peculiar variety of porphyritic granite, in which the felspar is of a flesh-colour, and often in large, regular crystals. Of the granite which I found in place, in the interior of the Chippewa Land District, along my route to Lake Superior, that which was found at the first rapids of the Court Oreille River comes nearest to the composition and appearance of these prairie boulders. This, however, can hardly be the source whence they have drifted; for the direction of the belt of erratics does not appear to be transverse to the streams, that is, from northeast to southwest, but rather parallel with them, from northwest to southeast.

The only explanation that is at all satisfactory in accounting for the transporting

power which has brought these detached masses of granite rocks into their present position, is floating ice—ice drifted by currents setting in from the north, before the land emerged from the ocean, in the same manner as, at the present time, thousands of tons of rock are precipitated on the bed of the Atlantic Ocean from icebergs, which annually work their way from the north, and melt in southern latitudes. No mere currents appear at all adequate to convey such heavy blocks across valleys, and over hills, to a distance of hundreds of miles from the parent rock. Their isolated position in the prairie also indicates that they were dropped into their present situation, rather than rolled into it. Under the latter supposition, even if it were possible, they would probably be closer together, and more regularly assorted as to size.

SECTION II.

THEIR PALÆONTOLOGY.

No fossil remains of any kind have been observed either in the drift deposits or in the stratified rocks intervening between the Protozoic Sandstones of Wisconsin, and the Crystalline Rocks.

Hereafter, especially in making deep cuts for railroads or similar improvements, such may come to light, in some of the superficial drift formations, since these have furnished, in Canada, and, in some rare instances in Europe, a few organic exuviæ.

SECTION III.

THEIR MINERAL CONTENTS.

Isolated masses of native copper, and small portions of other ores, are not of unfrequent occurrence in and amongst the numerous boulders accumulated in the river beds.

All appearances go to prove, that these ores have a common origin with the accompanying erratics; or, in other words, that they are no longer in place, but have been transported to greater or less distance, from the trap ranges, where they originated, to their present location.

The drift deposits are, therefore, but the secondary repositories of these ores, which occur over their surface, at wide intervals. It is not within reasonable expectation that they should be found in quantities sufficient to justify the expense of searching them out, and collecting them together, from their distant and scattered localities.

Indications of ore in place were occasionally observed embedded in the substance of granite, syenite, and greenstone, on several branches of the Chippewa. But these have almost uniformly proved to be mere varieties of iron pyrites, in which analysis has failed to detect any admixture of metals more valuable than iron.

I remark, however, that the granite, in the vicinity of Vermilion Rapids, of the Chippewa, bears a close resemblance to the granite of Limoges and Chauteloupe, in the Department of the Haute Vienne, in France; in which latter are found emeralds, phosphate of lime, phosphate of iron, phosphate of manganese, phosphate of uranium, variegated copper, arsenical iron, oxide of tin, kaolin, and garnets.

Though none of these minerals were discovered on the surface, within the range of our observations, it is possible, that mining operations, carried to some depth in that formation, might disclose one or other of them. Unless, however, future superficial examinations disclose more encouraging indications than anything we have yet met with, the chance of productive return is, in my judgment, too small to justify such an enterprise. Mining operations would here be conducted under great disadvantages. The rocks usually lie so near the level of the general drainage of the country, that shafts and adits would be most likely speedily inundated; and, at any considerable distance from the rivers, the expense of sinking through a thick mass of loose, incoherent, superincumbent material, would be a source of great expense.

As heretofore alluded to, near the junction of the green and red chloritic schistose rocks, on Township 21 north, and Range 4 west, these rocks assume a highly ferruginous character, and pass gradually into heavy beds of oxide of iron; and magnetic disturbances, observed during the land surveys in that neighbourhood, prove these iron beds to be of considerable extent. Mr. J. P. Cathcart's survey of the townships on Black River showed, on the line between Townships 21 and 22, of Range 3 west, of the 4th Principal Meridian, running west, a variation first of 8°; at the end of the first forty chains, a variation of 2° 15′; at the end of the next forty chains, of 2° 30′; at the end of the first mile, of 5°; at the end of the next mile of 13° 35′; the average variation being 8°.

Near the Falls of the Chippewa, in a similar geological position, I observed similar indications of iron.

On the head-waters of Prairie à la Crosse, Mr. Dunn, United States Surveyor, noticed extraordinary variations of the needle, ranging from 5° 20′ to 17° 30′. There is good reason to believe that, at these and probably at other localities along the range of the same formation, bodies of iron ore exist, in productive quantities.

Some earthy carbonate of copper has been found in place, to a limited extent, in connexion with the Trap Ranges of the St. Croix, but not in sufficient quantities or richness* to induce those holding claims to undertake mining operations.

In addition to the considerations derived from the average yield of the copper earth, and the poorness of the superficial veins, it may be useful to remark, that the Trap Formation of the St. Croix, though probably a spur from the Porcupine

* A sample of copper ore, said to have been obtained from a crevice in the trap near the Mill on the St. Croix, was taken to Boston, and analyzed by Mr. Hayes, who found it to contain, according to the statement of Mr. Brownell, 19·77 pure copper.

Average samples, obtained near the same place, were subjected to analysis in my laboratory, with a very different result, the ore itself only yielding, on an average, four to five per cent., and the poorer copper earth but one to two per cent. I am induced to believe that the discrepancy in the two analyses arises from the fact that Mr. Hayes was handed for examination a choice, picked specimen.

Range, is a mere outlier, removed from *the main axis of upheaval* by a distance of over two hundred miles; that the greater portion of the intervening country, as shown by the survey, is covered by an extensive deposit of drift, through which the igneous rocks seldom penetrate, and when they do, never attain any great elevation above the surrounding country; that, moreover, though the dykes and ridges form a prominent feature of the country over a few sections of land, these soon lose themselves under swamps, accumulations of sand, gravel, and erratics. They seem, in fact, but the effects of the expiring throes—the last heaving efforts of subterranean volcanic fires, shooting in a linear direction from the shores of Lake Superior to the southwest, that retained force sufficient to burst through the superincumbent impediments, and inject their molten material over a circumscribed area above the general drainage of the country; and hence could hardly be expected to yield lasting and productive metallic treasures, unless by deep-seated, laborious, and expensive mining operations, in which few would be willing to embark, especially when these have to be undertaken in a hard and refractory rock, like the trap of the St. Croix.

SECTION IV.

ITS RANGE, EXTENT, AND BEARING.

Under the title of "Formations of the Interior of Wisconsin and Minnesota," I purpose to comprehend all of Wisconsin lying north of the lowest Protozoic strata, as far as the sources of streams emptying into Lake Superior, together with Southwestern Minnesota, including the Valley of Red River of the North.

GRANITIC RANGE, FALLS OF THE CHIPPEWA.

As a whole, this part of the District may be regarded as a vast region of drift; since the area of actual exposure of igneous and metamorphic rocks is quite limited, being confined chiefly to a few points in the valleys of rivers where the streams

form falls or rapids, to partial outcrops in the ridges, between the waters flowing into the Mississippi and Lake Superior, and to somewhat more elevated and extensive ranges along the extreme northern limits of the United States. It is altogether probable, however, that at least one-half of the drift region is based on gneiss, mica-slate, other metamorphic schists, and granitic rocks; while the other half is underlaid by Protozoic sandstones.

SECTION V.

THEIR PHYSICAL AND AGRICULTURAL CHARACTER.

The principal exposures of Protozoic Strata pertaining to F. 1 and F. 2, which have been the subject of the first chapter, extend, as I have there shown, as far as the falls of the eastern tributaries of the Mississippi. The average distance of their northeast line of limit from that river, in a direct course, may be from fifty to seventy miles, or, by the meanders of the streams, ninety to a hundred miles. There the crystalline rocks emerge from beneath the water-courses, as seen in the cut on page 147.

This change in the geological formation of the country is accompanied by a corresponding change in its physical features. Just before reaching the igneous ranges, the streams are usually hemmed in on either side by solid walls of sandstone (F. 1, *a*), known, as already stated, by the name of *Dalles*. A few miles beyond these commences a succession of low falls and rapids, which interrupt navigation, and render portages necessary before the traveller can advance even with a bark canoe. These obstructions are formed by outbursts of igneous rocks.

The elevating forces which have brought these to the surface, through the interior of the District, have not been sufficient to produce hills of any great height, such as are usually to be found in regions of crystalline rocks, that constitute extensive water-sheds. On the contrary, though we here approach the dividing ridge, whence rise, on one side, many of the most important tributaries of the Mississippi, and on the other, numerous streams emptying into Lake Superior, we find a level country, or at least merely a succession of low, flat plains, rising twenty-five to thirty feet, one above another,* with intervening ridges one to two hundred feet high. It is at the commencement and termination of the former that the principal falls and rapids set in.

The soil prevalent over the drift region under consideration, is, as a general rule, especially in the southeast, poor, thin, and seldom above second-rate character. In a country of this description, one is, at first, surprised to encounter a multitude of lakes, ponds, and swamps, to such an extent as to render travelling, even on horseback, hazardous. This seems little in accordance with the porous, siliceous character of the superficial deposits over this region. The explanation is, that these are underlaid by clays and argillaceous beds, highly retentive of moisture, and derived,

* On the Upper Wisconsin, the crystalline rocks are elevated several hundred feet above the river, but this is an exception to the general rule through this part of Wisconsin.

doubtless, from the decomposition of the felspathic granites and argillaceous schist, on which the whole reposes.

Towards the heads of the streams, the standing water is often so great, and the surface covered to such an extent with erratics, as to be scarcely habitable, except by a race, like the Chippewa Indians, content to subsist on fish, wild rice, and the sugar of the maple. It is but here and there fit for agricultural purposes; and these arable tracts are chiefly confined to narrow strips, bordering the larger lakes and streams.

In striking contrast with the above is the soil overlying the igneous ranges,* rich, black, and of remarkable fertility, but often low and wet, and embarrassed, like the preceding region, with large, loose blocks of stone.

This section of country is chiefly inhabited, at present, besides Indians and half-breeds, by men exclusively engaged in the lumber trade.

The importance of this trade may be judged from the following statistics, collected, in 1847, by Mr. Randall.

The lumber is chiefly manufactured on the Wisconsin, Black, Chippewa, and the St. Croix Rivers, and their tributaries.

On the Wisconsin River are twenty-four mills, running forty-five saws, and sawing about nineteen and a half millions of lumber, worth, at the mills, about six dollars a thousand, and three millions of shingles, worth two dollars a thousand. The total value of the lumber on the Wisconsin for that year was, therefore—

19,500,000 feet, at $6 per M. feet,	$117,000
3,000,000 shingles, at $2 per M.,	6,000

On Black River and its tributaries there are thirteen mills, running sixteen saws, and turning out six millions three hundred and fifty thousand feet of lumber annually; one and a half million of shingles, and forty-five thousand feet of square timber, say—

6,000,000 feet, at $6 per M.,	$36,000
1,500,000 shingles at $2 per M.,	3,000
45,000 feet square timber at $25 per M.,	1,125

* The analysis of soil from the vicinity of a trap ridge near the Falls of the St. Croix, yielded—

Water,	2·25
Organic matter,	7·25
Silicates insoluble in hydrochloric and sulphuric acids,	81·44
Alumina, soluble in hydrochloric acid,	1·14
Oxide of iron, soluble in hydrochloric acid,	1·50
Silica, soluble in hydrochloric acid,	0·05
Carbonate of lime,	1·40
Magnesia,	0·37
Chloride of potassium, with a trace of chloride of sodium,	0·15
Alumina, soluble in sulphuric acid,	1·83
Loss, and inorganic acids not determined,	2·61
	100·00

On the Chippewa and its tributaries there are five mills and seven saws, which manufacture five millions three hundred and fifty thousand feet of lumber; three millions one hundred thousand laths; one million three hundred thousand shingles, and fifty thousand feet of square timber; there are also sent to market about two thousand logs, say—

5,350,000 feet of board and plank, at $8 per M.,	$42,800
3,100,000 lathing, at $2 per M.,	6,200
1,300,000 shingles, at $2 per M.,	2,400
50,000 feet of square lumber, at $30 per M.,	1,500
2,000 logs, at $2 each,	4,000

On the St. Croix and its tributaries five mills and twelve saws are in operation, which cut, during 1848, seven million seven hundred thousand feet of boards and plank; six million laths; one hundred thousand shingles; besides fifteen thousand logs taken to market without sawing;* say—

7,700,000 feet, at $8 per M.,	$61,600
6,000,000 laths, at $2 per M.,	12,000
100,000 shingles, at $2 per M.,	200
15,000 logs, at $2 each,	30,000

By the time this reaches the St. Louis market, its value is nearly doubled, so that the actual income to the inhabitants, in 1847, was upwards of half a million of dollars.

According to the calculation made in the pine regions of New York and the New England States, of the quantity of lumber which one acre of ground will produce, *five thousand* acres of land must annually be denuded of its timber to furnish the lumber sent into market from the Chippewa Land District. A portion of this land, when deprived of its timber, is almost worthless.

The Chippewa Land District is the country which must ultimately supply, with pine lumber, the whole Mississippi country below the Wisconsin River, and north of the mouth of the Ohio; for, south of the Wisconsin, there are no pine lands of any extent. The future importance and value of the trade can well be appreciated by those who have witnessed the rate of immigration into these vast and fertile plains of the United States, particularly when they consider the preference given to wooden buildings in the West, and the immense consumption of building material, not only in the larger cities, but also for the construction of those numerous towns and villages which spring up, as if by magic, along the shores of the Mississippi and its tributaries.

* The steamboat War-Eagle towed out of Lake St. Croix, at one time, a raft of logs and sawed lumber which covered, by measurement, eleven acres.

SECTION VI.

ITS LOCAL DETAILS.

Crystalline Ranges of Wisconsin.—The most southwesterly exposure of granitic rocks on the tributaries of the Upper Mississippi, is on Black River.* The locality of their first outburst is on the northeast portion of Township 21 north, Range 4 west, of the 4th Principal Meridian. The predominating rock is pure granite, associated with a gray syenitic rock. An extensive sand prairie stretches away to the south of this range, formed by the debris of the lower Protozoic sandstones, and having much the appearance of the great sand plains on the Wisconsin River, south of Whitney's Rapids, represented by the topography on Section No. 3, S.

North of the granitic range, a bed of greenstone trap, about thirty feet wide, crosses the bed of Black River, and is exposed a few feet above the water-level. In contact with this, are green and red chloritic, schistose rocks on Township 21 north, Range 4 west, of 4th Principal Meridian; some of the latter is highly ferruginous, and passes gradually into heavy beds of brown oxide and magnetic iron ore. Here the magnetic needle has a considerable local variation over an area of several miles square.

The magnesian slates, above mentioned, show themselves on the river for the distance of nearly a mile, capped unconformably by a pebbly sandstone, F. 1, *a*, as shown on Section No. 1, R, constructed from observations by Mr. Randall. Though the soil of this township is sandy, from drift materials derived from the adjacent sandstones, still it is of much better quality than that further south, and southwest, where the Protozoic sandstones of Black River alone occupy the surface. It supports a growth of yellow pine.

Four to six miles northeast of the Falls of Black River, in Townships 21 and 22 north, Range 3 west, of the 4th Principal Meridian, there are outliers of the above sandstone formation, forming hills of seventy to one hundred feet in height; on Sections 4 and 33, 5 and 32, 1 and 36, of the above townships, some of its beds are impregnated with iron to such an extent as to render it impracticable to survey the country with any degree of accuracy with a common magnetic needle: the variation along the line between these townships is in some places even as great as 13° 35′.

After passing the east fork of Black River, the crystalline rocks extend, with few exceptions, nearly to the tops of the highest hills, with only here and there a capping of pebbly sandstone. Through this granitic range, the soil is much improved, and the land well timbered with hard wood and white pine of superior quality.

Immediately after crossing Cunningham's Creek, a gneiss formation takes the place of the granite, and extends some five or six miles.

* The late Mr. J. S. Thayer observed a locality of granite in Dodge County, Wisconsin, on the west branch of Rock River, on Section 33, Township 9 north, Range 13 west, of 4th Principal Meridian. This is nearly on a parallel of latitude with Painted Rock, on the Mississippi, and about one hundred miles east of these granitic ranges, on Black River, and distant at least one hundred and twenty miles from the Mississippi, and between fifty and sixty west from Lake Michigan.

From O'Neil's Creek, in Township 24 north, Range 2 west, to Wedge's Creek, in Township 25 north, Range 4 west, the only rock observed was a single ledge of pebbly sandstone, twelve feet above the surface; even boulders, which are so numerous further north, are absent; but the character of the surrounding country is similar to that above the forks, where granites are in place. Beyond Wedge's Creek the soil is more sandy, and pine timber more abundant, but not of as good quality as that north of the east fork of Black River.

In Township 26 north, Range 2 west, is an isolated hill, one hundred and fifty feet high, composed of compact sandstone (F. 1). Others can be seen in the distance to the west and south. On the northeast of Townships 26 and 27 north, Range 3 west, on the head waters of the east branch of the L'Eau Claire, granite is exposed, of similar colour and structure to that on the Falls of Black River. The country southwest of this Range, lying between Black River and the forks of the L'Eau Claire, becomes gradually more sandy. This is the boundary between the inferior sandstone of F. 1, and the crystalline rocks, and the northeast margin of that sandy belt of country heretofore noticed in the description of the Lower Chippewa River.

Conspicuous outliers of F. 1, *a*, can be seen stretching away to the southwest, some of which, near the L'Eau Claire, are capped with a Lingula sandstone.

The last rocks seen in place by Mr. Randall, on the head waters of Black River, were on the northern part of Township 28, between Ranges 1 and 2 west. It is a low range of chlorite slate, of a similar character and composition to that above the Falls of Black River.

Beyond this, after passing the Correction Line, the country becomes flat and swampy, and, except limited spots, almost worthless for agricultural purposes.

No metallic veins were noticed by Mr. Randall traversing any of these crystalline ranges on Black River, within the limits of the Chippewa Land District; indeed their elevation above the water-courses is for the most part so slight, that there is little or no prospect of their ever becoming valuable as mineral lands.

After the 4th Principal Meridian crosses Black River, no rocks but boulders appear on the surface for sixty miles; indeed, it traverses an almost continuous swamp in Township 40. Here the crystalline rocks again protrude, and form precipitous cliffs on the Upper Rapids and Falls of the Manidowish, of twenty to thirty feet in height. On this stream, where the Meridian crosses it, the rock differs but little from the graphic granite of the Falls of the Appomattox. The felspar, which enters largely into its composition, is of a light bluish pink, with a glistening vitreous lustre; disseminated through it is only a small proportion of quartz. Two miles below, on this river, the granite is traversed by veins of gneiss. Granitic and hornblendic rocks are exposed, with little interruption, along the course of the Manidowish to within fourteen miles of its confluence with the Chippewa, where the pebbly and lower sandstones of F. 1 cross the river. Below this, the crystalline rocks are only seen on the surface, for a short distance, when they disappear beneath deposits of drift.

From the Manidowish to the north part of Township 43, there are a succession of maple ridges and intervening tamerack, cedar, and alder swamps, the former of

greatest extent; the latter varying from a quarter of a mile to a mile in width. On the ridges, besides maple are found elm, birch, balsam-fir, hemlock, and hazel.

For fourteen or fifteen miles north of the Manidowish, on the meridian line, no rocks but boulders were seen on the surface. On Sections 1 and 2, Township 44, a granite is again in place, possessing the character of that on the Falls of Black River. This is the most northerly outburst of granitic crystalline rocks which was observed on the 4th Principal Meridian.*

The igneous ranges first show themselves in the bed of the east branch of the Chippewa. This stream was explored by Dr. Litton, who reports his observations on the L'Eau Claire, as follows:

" Dalles, formed of the sandstones of F. 1, *a*, commence almost immediately on entering the river, but extend only a few hundred yards. For twelve miles above the mouth, coarse quartzose sandstone is the only rock visible; this extends, in every case, from the level of the river to the very highest point that I found rock exposed. About fourteen miles above the mouth, the crystalline rocks are in place. They present themselves, on one side or other, at distances varying from two hundred yards to a mile, up to the Falls, which, by the course of the river, are twenty miles from the mouth. At the Falls, the rock is composed chiefly of hornblende, and possesses a crystalline structure; it is exposed on both sides of the river, but does not rise higher than twenty feet above the water. The general level of the country is about sixty or seventy feet higher. Associated with the hornblende rock, above the Falls, are both gneiss and chlorite slate; the former in a state of decomposition. These are exposed for seven or eight miles, never rising to a height of more than twenty feet above the river bed, and frequently not more than ten feet, or even less. Everywhere, except on the river bank, these igneous and metamorphic rocks are covered with a drift of sand.

" Four miles above the Falls, a pink granite was observed, containing large plates of gray mica, and masses of flesh-coloured felspar. Sixteen or seventeen miles above the Falls are Dalles similar to those below the Falls. They are not formed by the crystalline rocks, but by the same coarse-grained sandstone observed below the Falls, which rises to the height of sixty or seventy feet above the level of the river, and extends along the stream some two hundred yards.

" Twenty-five miles above the Falls, the intrusive rocks are again in place, for at least eight or nine miles, and form a chain across the river, producing a succession of rapids, that obstruct its navigation, known as the Little Falls.

" Two miles above the Little Falls, and about thirty above the main Falls, pebbly sandstone, of F. 1, *a*, rests upon decomposed green, gray, and reddish clayey-materials, derived from the decomposition of a rather close-grained granite, destitute of mica, but containing abundance of felspar.

" So great is the body of sand which overlies the igneous rocks here as elsewhere

* For a further description of the 4th Principal Meridian, see Colonel Whittlesey's Report. Section No. 2, R, constructed by Mr. Randall, shows the succession of the formations from Lake Superior to the Mississippi, along the line of the 4th Principal Meridian.

on the L'Eau Claire, that the soil can derive little fertilizing chemical principles from the intrusive rocks; it is generally but little better than that of the sandy region of the Chippewa, above and below the mouth of the Menomonie.

" From all that was observed of the geological features of the country on the L'Eau Claire, there is little probability of its affording productive ores. The only metallic mineral noticed, associated with the crystalline rocks, on this river, was yellow sulphuret of iron, disseminated through the hornblende rock."

Dr. Litton, who also explored the Menomonie, did not observe, on this western branch of the Chippewa, any crystalline rocks in place on the surface, in any part of its course, as far as he ascended it, viz., to the forks of the two small branches which proceed from a series of lakes forming its head waters. There is, however, reason to believe, from observations on the streams east of it, that they cannot be far beneath the surface here, especially as Mr. Randall found, at the pipestone locality, fifteen to twenty miles east of the Menomonie, beds partially metamorphosed, such as we have usually found lying in close proximity to the crystalline formations.

Dr. Litton also ascended Prairie à la Crosse River, fifty miles above its mouth, by the course of the stream, and Mountain Island River, ninety to a hundred miles; and Mr. Macy explored Buffalo River for about forty miles. On none of these streams were any intrusive rocks found in place.*

On the main branch of the Chippewa, the first crystalline rocks which were observed on the surface were just above the Dalles, about ninety miles by the course of the river from its mouth.

On the east side of the Chippewa, about twenty to thirty feet above the bed of the river, and a short distance below Allen's Mills, is a deposit of the earthy brown oxide of iron, which appears to be extensive. It is of a variety that would be easily wrought in the furnace.

The quartzose granite, at the Falls, immediately above, contains but little mica. On the northwest side of the river, a considerable portion of flesh-coloured felspar enters into its composition, and is disseminated in veins; its structure is rather subcuboidal. On the southeast side the felspar is lighter coloured, and the rock of the character of gneiss, whilst other parts of it look almost like a metamorphic sandstone. In consequence of the great flood which occurred just at the time we were there, I had not an opportunity of examining the rock to advantage, since very little of it was exposed above high water. The wood-cut on page 147, representing the Falls of the Chippewa during the flood of June, 1847, shows the exposure of the crystalline rocks as they appeared at that time.

Near the head of the portage above Ganethie's trading-post, at the mouth of Cut Rock, solid ledges of sandstone, F. 1, *a*, are again in place, on the west side of the

* The strata which prevail on the west branch of the Chippewa belong chiefly to F. 1, *d*, and F. 1, *e*, i. e., to the Lingula sandstones and Trilobite grit, treated of in Chapter I. On Mountain Island, Prairie à la Crosse, and Buffalo Rivers, the same beds form, together with F. 1, *c*, the principal parts of the hills, capped sometimes with F. 2.

river, but no crystalline rocks are visible above the level of high water. The sandstones at this locality are remarkable for their cross lines of deposition.

The beds lie in the following succession, from above downwards, as measured by Mr. Randall:

	Feet.	Inches.
1. Drift,	10	
2. Soft, white sandstones, with thin, schistose layers between the beds,	10	
3. Fine pebbly sandstone, with oblique laminations,	8	
4. Hard, thin layers of sandstone,		9
5. Sandstone with brown streaks; schistose layers interlaminated,	8	
6. Hard brown sandstone, in layers from 1 to 4 inches,	1	6
7. Soft, white sandstone, with remarkable oblique lines of deposition, the angles varying from 15° to 45°,	5	
8. Fine pebbly sandstone,	5	
9. Fine pebbly sandstone, with oblique lines of lamination,		6
10. Schistose layers of sandstone,		6
11. White sandstone, with layers of fine pebbles,	8	
12. Soft, white sandstone,	6	
13. Pebbly sandstone, the pebbles about the size of a pea, 2 feet above water,	2	

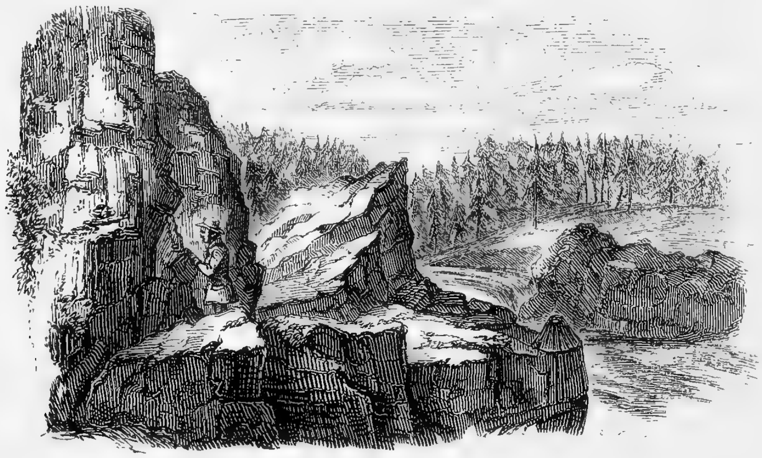
These sandstones have a dip to the south-southwest, sometimes to the extent of 10°. They are seen in the cuts of the streams to within a mile of Vermilion Rapids, where the pebbly sandstone is exposed for fifteen feet, overlying crystalline rocks, and shows apparent marks of disturbance and dislocation. Three miles west of this junction, Lingula sandstone, F. 1, *c*, caps the hills.

Six or seven miles above Cut Rock, there is a portage of four and a half miles over Vermilion Rapids. Here there is a greater variety of rocks than on the Falls of the Chippewa. In the space of one mile, I observed fine and coarse-grained granite, with masses and veins of pink and white felspar, hornblende rock, gneiss traversed by veins of quartz and petrosilex, mica-slate passing into chlorite-slate. The lamination of the schistose rocks is nearly vertical, and their bearing at different places varies from 10° to 20° north and south of a due east and west course. At the time I was there, the high water prevented a critical examination; but Mr. Randall, in his descent from the Manidowish, passed afterwards over this Rapid, in October, when the water was quite low, and made some additional observations. He found gneiss and hornblende rock to prevail; the former much contorted, and traversed by pyramidal dykes of massive quartz, running into a petrosiliceous rock of a gray colour. On the southeast bank, resting on the crystalline rocks, are drift deposits, in the following order:

	Feet.	Inches.
1. Soil,		15
2. Subsoil, light yellow sand,		15
3. Fine drift, pebbles not over half an inch in diameter,	4	
4. Coarse drift, pebbles chiefly crystalline and trappean rocks,	4	
5. Red, marly drift, pebbles chiefly red sandstone,	4	
6. Coarse drift, with dark yellow sand,	15	

Two to two and a half miles above the head of this portage are rapids, where a chain of close-grained quartzose granite, not unlike that of Woodstock, in Maryland, forms the river bed. Above the head of these rapids, gneiss is in place, traversed by veins of granite. Two and a half to three miles higher on the Chippewa, greenstone and hornblende schist protrude, where the rapids again commence.

Twelve miles above Vermilion Rapids is Brunet's Portage and trading-post. By water, this portage is about three-quarters of a mile, by land one mile. The Chippewa is here lined on either side by a dense forest of moderate-sized pines. The rocks are more elevated here than at Vermilion Rapids, and the fall is greater,—about thirty-six feet from the foot to the head of the portage. Hornblende predominates in the rocks of this locality. It is seen in some of the beds in distinct crystals of a quarter to half an inch long. Some portions of the rock have the appearance and subcolumnar structure of basalt; other portions are schistose. At the most turbulent part of the Chippewa, at these Rapids, the rock is more of a bluish pink, quartzose granite, and presents the appearance seen in the annexed vignette.



HORNBLENDIC AND GRANITIC ROCK, BRUNET'S PORTAGE.

This is one of the most important axis of elevation of the crystalline rocks of the Chippewa, and attracts the attention of the geologist the more, since the structure of the rock partakes of the character of the granitic rocks of Central France. The circuitous waters of the Chippewa here foam around piles of rock, that obstruct its passage, as it winds its way through the dark pine forest, and lends some variety and interest to the scenery of this part of the Chippewa, which is, for the most part, too same and flat to be otherwise than monotonous and tame.

Six miles above Brunet's, is another portage, of half a mile. Here also hornblende is the principal constituent of the rocks; but they are closer grained and more siliceous than at Brunet's, and they are associated with a kind of petrosiliceous, schistose rock, with a very uniform cleavage angle of 26°. The general bearing of the beds is east by north and west by south.

Above this portage some six miles, and about one mile below the confluence of

the Chippewa and Manidowish, are some fine pines, intermixed with maple and other hard wood.

The drift deposits here are similar to those observed at Vermilion Rapids, only No. 4 of the Section is better developed. After passing the mouth of the stream, no rocks were perceived in place, until two miles above the mouth of the Whip River, where there is some fine-grained pink and gray granite. For two or three miles here the current of the Chippewa is very swift, and the banks are lined with boulders.

A mile or two further on, and three to four miles above the mouth of Whip River, I observed some syenitic granite, traversed by veins of reddish granite. Similar rocks were in place, every few miles, to the mouth of Court Oreille River.

Soon after entering this branch of the Chippewa, we came to rapids, formed by a chain of porphyritic syenite, and the same kind of rock is seen in several places between this and the portage, two to three miles above the mouth. The syenite has much the appearance of that which occurs at St. Julien, in France.

The fall of the river, at the portage of the Court Oreille, is about fourteen or fifteen feet. Huge blocks of syenite, covered with different kinds of moss, may be seen projecting amongst the pines that line the adjacent bank. On this part of the river there is no high ground in sight; the surface is mostly covered with drift, composed of sand, gravel, and boulders.

A succession of rapids, with very little still water, continues for fourteen to sixteen miles. Wherever the water is swift, the bottom of the stream is covered with boulders, and huge blocks of crystalline or trappean rocks project out of the water, either in place, or not far removed from the parent mass.

This is the character of the river to within six or eight miles of Lake Court Oreille. There the country becomes more open; the dense pine forest gives place to a more stunted growth of evergreens and aspen. A few hills of drift appear in sight; one of these measured one hundred and twenty-five feet above the level of the river. The general face of the country, however, for four or five miles before reaching the lake, is very little elevated above high-water mark, and it supports only such growths as flourish in swampy ground. A few stunted and half-decayed pines were the only trees visible.

At Corbin's Trading-Post, near the entrance of Lake Court Oreille, the banks are elevated twelve or fourteen feet above the level of the lake, and the height beyond, inhabited by the chief of the tribe that resides in the vicinity of the lake, is still higher, about twenty feet. This spot presented a very fine appearance at the time we visited the place, in June, the green slope extending down to the edge of the water. All the elevated land around this lake is composed of drift, in which sand is the predominating ingredient.

It is said, that between the upper and lower rapids of the Court Oreille River, a copper boulder, weighing more than one hundred pounds, was found by the Chippewa Indians; this was probably an erratic mass.

The lake has a very narrow entrance; the channel is only some twelve or fifteen feet wide. The greatest length of the lake is said to be nine miles from north-

east to southwest. Its waters are clear, and not coloured brown, like those of the Court Oreille and the Chippewa Rivers.

From the lake we passed, by a very narrow channel, through water-lilies and bulrushes, into Lac Grit, or Grindstone Lake. This is also a fine expanse of water, which has received its name from a kind of grit or grindstone found on the north shore. On examining the spot where they are procured, I found the shore thickly lined with boulders, and, some distance from the bank, loose masses of a buff-coloured freestone. The lighter coloured of these gritstones resemble some of the members of F. 1; the pink varieties, and especially those that are spotted, have more the aspect of the Lake Superior formations. The partial exposure of this rock renders it difficult to decide to what member of F. 1 it belongs; it seems probable that we have here the transition between the lowest beds on the Mississippi to those of Lake Superior.

From Grindstone Lake, we made a portage of half a mile, to Lac Vollé, or Lily Lake, a small sheet of water, about half a mile in length. From this lake to the Namekagon River, is another portage, between four and five miles. The trail leads over a ridge, which overlooks a considerable extent of country. In consequence of a thunderstorm, which caused considerable oscillations of the mercury, I could not make very accurate observations on the relative level of Lac Vollé and Namekagon River. The height of the ridge in sight of the Namekagon is one hundred and two feet above that stream; and a high point to the right, on the southwest of the trail, near the same place, is thirty-six feet higher. Nothing but drift could be seen in any of these hills; the prevalent growth is birch.

On arriving at the Namekagon River, two of our party descended that stream, with one canoe, to its mouth; the rest ascended it, on the route to Lake Superior by the way of Mauvaise Rivière.

The Namekagon River is about fifteen to twenty paces wide, with banks from eight to twelve feet high. The prevailing growths are pine and birch, usually of small size; the undergrowth is chiefly ferns. The soil is thin, sandy, and gravelly, not much better than that on the Chippewa below the Dalles; the land level, and the woods open. The only rocks visible are boulders, which are chiefly varieties of trap, from the size of a half bushel measure to that of small pebbles.

The sandy nature of the soil, on this portion of the Namekagon, favours the idea that the nucleus of the knolls and hills is sandstone.

About fifteen miles from the point where we embarked on the Namekagon is a small lake, known by the name of Little Rice Lake. A mile or so beyond this, low hills appear on the river, on the northwest. They are from twenty-five to thirty feet high, and are composed of drift. These appeared at intervals, for four or five miles, to the "Big Pine" Encampment, above the Snake Rapids, where these hills of drift were found to be seventy-one feet high. Their summits command an extensive view. To the northeast the country is tolerably open, but on the opposite side of the Namekagon, in a southwest course, a pine forest bounds the prospect. No ledges of rock were visible, but large boulders are strewn on the surface and also in the bed of the stream at the Rapids.

Nine miles by water from Little Rice Lake, and six or seven miles by the trail,

is Great Rice Lake, which is merely an expansion of the river. It has anything but an inviting appearance. The blades of wild rice which rest drooping on its waters almost cover the surface. At the season of the year when I visited it, it had all the appearance of that green scum often seen in stagnant pools, caused by a growth of *Confervæ.*

The soil on the north side of the Namekagon, between these two lakes, is of the same sandy character which generally prevails in the pine lands of those regions, where extensive deposits of drift have been derived from the destruction of pre-existing sandstones. On the south side it is probable that the soil is of better quality, since the timber is of larger growth.

Above Great Rice Lake, there is a succession of swift rapids, in which the trappean boulders are so numerous that it is difficult to avoid them in navigating the stream. Some of them are of large dimensions.

The waters of the Namekagon are not as highly coloured as those of the principal branches of the Chippewa, but they are warmer and less palatable. The Indians who inhabit its banks are wont, before drinking it, to mix it with maple sugar.

Six or seven miles above Great Rice Lake, our party left the Namekagon, in order to gain the head waters of Mauvaise Rivière, through a series of lakes which lie to the north.

The first of these we reached by a portage of about one mile. It is known by the name of Leech Lake, no doubt from the number of leeches which infest it. The length of the lake may be about half to three-quarters of a mile. The shores are lined with boulders of trap, granite, gneiss, and porphyry. Of the latter I observed a peculiar variety: the base is composed of a light-coloured felspar, with embedded particles of quartz, about the size of the pupil of the eye; many of them are coated over with a green mineral substance, which is either a kind of epidote or serpentine.

The next lake is called Island Lake, on account of a small and rather handsome island in its centre, covered with small birch trees; the portage to this lake is one-third to two-thirds of a mile. Its dimensions are about the same as those of Leech Lake.

The third lake is Little Lake, distant about two-thirds to three-quarters of a mile north of Island Lake. It is from half a mile to three-quarters long, and from a quarter to two-thirds wide. It is surrounded by a mossy swamp, in which that remarkable flower, *Saracenia Purpurea,* with its pitcher-shaped leaf, grows abundantly. It was in bloom when we were there,—the 30th of June.

Between these two lakes are to be found many mottled dark gray trappean boulders, similar to some I noticed on the Chippewa. The portage between these lakes passes over low hills, of thirty to forty feet in height, composed of the same kind of drift as all the hills along the Namekagon.

The portage from Little Lake is northeast and southwest, or north-northeast and south-southwest.

Long Lake, the largest and last of the series, is six or seven miles long; it has a great many bays and inlets, with wooded promontories between. Our guide

informed us that the waters of the lake flow both ways from it: from its northeast end, towards the waters of Lake Superior; from its southwest extremity, towards the tributaries of the Mississippi. The appearance which it presents, seen from the southwest end, where the portage trail strikes it, is represented in the accompanying illustration.

The only living things which we noticed about these lakes, except a couple of Indians, who happened to be travelling the same route as ourselves, were several northern divers, *Colymbus glacialis*, whose shrill and peculiar cry rung through the solitude, at one time resembling the screaming of children in the distance, at others, imitating the sound of loud, convulsive laughter.

LONG LAKE.

As Colonel Whittlesey's Report gives a full account of the district bordering on Lake Superior, and extending as far back as the principal water-shed, on which Long Lake is situated, it would be superfluous to make any further remarks here on that region of country.

In continuation of further details regarding the interior of Wisconsin, I proceed, therefore, to the description of the Valley of the St. Croix, from the source of that stream to its Falls, where, as we have heretofore stated, the Protozoic sandstones, treated of in Chapter I., emerge from beneath the northern drift.

The portage trail which leads from the head waters of the Bois Brulé to those of the St. Croix, passes on the summit-level a ridge of drift, which is one hundred and twenty feet above Lake St. Croix, in which the stream of the same

name takes its rise. These heights command an extensive prospect of the surrounding country, which is clothed with evergreens. The landscape resembles, in its general features, the high ground of Keweenaw Point. About a quarter to half a mile east of the trail, and but little lower than the summit-level, is a small lake.

The head waters of St. Croix River proceed from a larger lake, about six miles long, and a half to three-quarters of a mile wide. The shore at the northern extremity is low, but on the east and west it is bounded by ridges twenty to thirty feet high, on which the growth is chiefly birch. Boulders of trap, granite, and hornblendic rocks line the margin of the lake. The channel of its outlet runs for three or four miles, like a canal, between fields of wild rice, interspersed with bulrushes and water-lilies. The temperature of the head waters of the Brulé is from twelve to fourteen degrees cooler than that of the St. Croix. This difference of temperature was found generally to hold good between the streams flowing into Lake Superior and the tributaries of the Mississippi.

Tamerack (*Larix Americana*) and cedar are the prevalent growths on the head waters of the St. Croix. Of the former, there are two species, or at least varieties; one, which frequents the wet, swampy ground; and the other, the low ridges. The leaves of the former are of a grayish green colour, and have the appearance of moss, at a distance, and the tree has a rugged look. The latter has a dark green colour, runs up into a pointed summit, and its whole outline is much more formal. I am not certain whether this is the *Larix microcarpa* of Lambert.

After descending about four miles, we found the channel very much obstructed by boulders, though the current was sluggish. Seven or eight miles below Upper Lake St. Croix, on the west side of the river, the trail which leads from Lake Superior strikes it. This is about two or three miles above the mouth of Schawaskosibi, or Green River, a tributary which comes in from the southeast. Soon after passing this stream, the velocity of the current increases a little, and the stream widens.

On the southeast is a ridge similar to the one crossed on the portage from the Brulé to the St. Croix, supporting a growth of the same kind of pine. This timber, however, is soon replaced by tamerack. From the appearance of these ridges, they would probably afford good ground for a road up the valley of the St. Croix.

About twenty-three or twenty-four miles below the lake, at the head of the St. Croix, the river expands into a small lake, or, rather, two lakes, connected by a bend of the river. At the foot of the lower of these, the first red sandstone which was observed in place reaches the surface. Here the rapids commence flowing over its horizontal ledges, which are much broken and split into pieces. The rapids are short, with slack water between. Two of these are very sudden, swift, and difficult to navigate. Trap boulders, some of which are large, fill the channel, and do not appear to be far out of place. The width of the St. Croix, at these rapids, is about twenty-five yards.

The red sandstone of this part of the St. Croix has numerous smooth and almost polished spots disseminated through it, more argillaceous than the body of the rock;

some of these have much the appearance of impressions of organic bodies, but they are so indistinct that no definite structure could be observed with a common magnifier.

From thirteen to fifteen miles from the head of the rapids, a dip was observed of the strata of red sandstone, in an east-southeast direction, at an angle of about 13°. It was only on the river that the sandstone could be discovered in place. Nothing but sand, gravel, and drift, could be found exposed on any of the ridges which I had an opportunity of examining, even to the height of one hundred or one hundred and twenty feet.

All the rapids above the mouth of the Namekagon seemed to be formed by ledges of the same red sandstone, varying from its usual appearance to that of a schistose argillaceous rock.

After passing the Namekagon a mile or two, there are no more rapids of any consequence, until after passing Yellow River.

The ridge over which the portage leads from the St. Croix to Yellow Lake, I found to be from eighty to a hundred feet high. Its direction is east-northeast and west-southwest, which, indeed, is the course of most of the ridges on the St. Croix, they being parallel with the trap ranges of the upper part of the Brulé. No trap can be seen here in place, nor, indeed, thus far on our descent down the St. Croix, probably on account of the thickness and extensive range of the drift deposits. The size and number of the trap boulders on the Rapids, and lining the shores, induce the belief that they are not far removed from the range of intrusive rocks from which they have been derived, and which probably constitutes the nucleus of many of the ridges of the Upper St. Croix.

About four miles below the Yellow Lake portage trail, a small stream flows into the St. Croix from the northwest, the Eninandigo River (?) of Nicollet, and two or three miles further, Turtle River enters from the southeast (Kayesikang or Shell River of Nicollet (?). A mile or two below this are banks of sand and gravel, similar to those described on the Lower Chippewa, but of a redder colour, and from twenty to seventy-five feet high.

There are many fine Unios in the St. Croix; most of the species seem to be the same as those found in the streams of the Western States, though they have a slightly modified outline of form. Among them I noticed *U. undulatus, siliquoides, crassus, cuneatus, mytiloides, gibbosus,* and *alatus.* These fresh-water mollusca seem to be more abundant on the St. Croix than on the Chippewa, Bad River, or the Brulé. A few were observed even as high up as the outlet of the Upper Lake St. Croix.

This part of the St. Croix is about sixty yards wide. It flows smoothly along, without rapids or ripples; the bottom is sandy, and boulders are less frequent along the shore.

The adjacent ridges seem composed chiefly of sand and drift, and are clothed with "pine openings." Four or five miles above the mouth of Kettle River is a beautiful stretch of bottom land, with picturesque groves of white oak and aspen, above the reach of high water. The soil, however, is light and sandy.

Just below this, a few boulders appear again in the bed of the stream, and rapids,

with a slight fall, set in, three and a half miles above the mouth of Kettle River. At the head of these I noticed the first range of trap unequivocally in place. It is of a cuboidal, or almost columnar structure; some of it is quite dark-coloured, almost black, with ferruginous stains; other portions are dark green and brown. A few hundred yards below this exposure, on the south side of the St. Croix, red sandstone is in place in a very shattered condition, resting on a conglomerate, which is slightly calcareous, its aspect having much the appearance of the Potomac marble, but the fragments of which it is composed are siliceous, with only a small proportion of calcareous cement. At a bend just below is a protrusion of trap, crossing the river obliquely, with a bearing nearly east-northeast and west-southwest. The upheaval of the trap has caused rapids here in the river, and has shattered the superincumbent beds, which are in a very broken condition. Below the bend on the same rapids, trap is in place, and can be traced to the height of fifteen to twenty feet above the river bed in the adjoining bank. The igneous outburst on this part of the St. Croix has not been sufficient to produce hills of any great elevation, twenty or thirty feet being the general height of the ridges here. Part of the rock of this range has an amygdaloidal structure.

This is doubtless the same trap range which Mr. J. Evans's party found crossing Kettle River, a few miles above its confluence with the St. Croix, and where some copper boulders have been found.

Three and a half miles below Kettle River, Snake River disembogues, on the west side; and one and a half to two miles further, horizontal strata of white and light yellow sandstones appear, fifteen feet above the river, on the east side of the St. Croix, covered with twenty to twenty-five feet of drift. No organic remains were discovered in these sandstones by which to determine their age; but the lithological character is like that of the sandstones of the Mississippi, and does not possess the red colour and argillaceous character of the sandstone three miles above Kettle River. The most southern limit of the red sandstones like those of Lake Superior, must be somewhere in the vicinity of Snake or Kettle Rivers. This member of F. 1, extends, therefore, much further down the valley of the St. Croix than down that of the other tributaries of the Mississippi. Its southern boundary, in a direct line, cannot be here over sixty miles from the Mississippi River.

Similar sandstones to those mentioned above, as occurring two miles below Snake River, are exposed at intervals, for the distance of several miles below, on the banks of the St. Croix. About eight miles below this first exposure, there is an outcrop on both shores; on the east side they are weathered into low arches. Some fine springs issue from the bank a few miles further; these are the first cool springs of water that we have noticed in our descent of the St. Croix.

Below this, no rock exposures were observed immediately on the river, only trap boulders occasionally lining the shores.

On both sides of the river, above Rising Sun, are some fine sites for farms; the ground is level, and the soil light, but rather siliceous.

Eight or ten miles below Rising Sun, the pines are replaced by a growth of hard wood.

The best pines for lumber are procured on Snake and Kettle Rivers, and other tributaries of the St. Croix. Those on the main stream are, for the most part, small.

Sixteen miles below Snake River, rapids commence again, and trap boulders become more numerous, some of them of large size. These rapids mark the place of the last range of intrusive rocks, viz., those which form the rapids, falls, and Dalles of the St. Croix, about thirty miles above its confluence with the Mississippi, represented by the wood-cut on p. 142. It consists of several subordinate ranges, belonging to the same general outburst, which vary from a hundred and fifty to three hundred and sixty feet in elevation: one, which crosses the river at the Falls, two or three above the Falls, and three or four below. Half a mile below the Falls, one of these ranges rises into perpendicular walls on both sides of the river, and constitutes the *Dalles* of that stream. Between these, the St. Croix rushes, at first, with great velocity, forming a succession of whirlpools, until it makes a sudden bend; then glides along placidly, reflecting in its deep waters the dark image of the columnar masses as they rise towering above each other to the height of a hundred to a hundred and seventy feet. The above-mentioned wood-cut and Section No. 3 convey an idea of the appearance and position of this range of trap below the Dalles of the St. Croix. It is one of the finest expositions of that kind of rock which I witnessed in the Chippewa Land District.

On the west side of the St. Croix, at the Dalles, forty or fifty feet above the present level of the river, are large *pot-holes*, some of which are twenty to twenty-five feet in diameter, and fifteen to twenty feet deep. These seem to have been worn into the solid rock by sand, gravel, and loose rocks, kept in motion by circular currents of water, similar to those now observed in the river at the head of the Dalles. They afford evidence, either of successive upheavals of the trap, or of the waters of the St. Croix having flowed formerly at a higher level.

Immediately at the Falls of St. Croix, the trap rock has nearly a homogeneous character; but on the high ridges on the west side of the river it is porphyritic, more so than any of the trappean ranges which came under my observation in Wisconsin. On Partridge Ridge, one mile west of the Falls, I observed a variety, the base of which is of a rich dark green, with embedded light pink lenticular crystals of felspar, and disseminated spots of epidote. This porphyritic trap differs but little from the Norway porphyry, found on the west side of the Christiana Fiord, near Bogstadt.

I caused a specimen of the St. Croix porphyry to be polished. It cuts easily, and its colours show beautifully; but in consequence of the epidote being softer than the basis of the rock, it receives an unequal polish, which diminishes its value for ornamental purposes.

Including the intervals between these trap ranges, they occupy a belt of country from fifteen to twenty miles in width. The outburst at the Falls of St. Croix, as heretofore remarked, has forced its way through highly fossiliferous strata, breaking up the beds immediately overlying it, entangling and partially indurating the fragments, without, however, tilting or metamorphosing the adjacent beds in any perceptible degree. The fossils, even of the beds almost in contact with the trap

dykes, are in a perfect state of preservation,* and the strata themselves have no dip perceptible to the unassisted eye in the hillside where they are exposed.

Section No. 3, showing the succession of the rocks as they occur from the mouth of the St. Croix, terminates with the above trap ranges on the north, and exhibits their position in connexion with the adjacent fossiliferous strata above described.

Drift and Crystalline Rocks between the Falls of St. Anthony and Crow Wing.—On the 28th of May, 1848, I reached the northern limit of the survey of 1847. Here I left the corps destined for the St. Peter's, to prepare for the ascent of that river, while I proceeded, accompanied by Dr. Norwood, up the Mississippi to the mouth of the Crow Wing, there to engage the necessary voyageurs, purchase canoes, and fit out generally for our separate routes to the north.

On my way to Crow Wing, but still better, on my return route down the channel of the Mississippi, I had an opportunity to observe what I had never been able satisfactorily to gather from the reports of other explorers; that is, the exact locality where the crystalline rocks are first seen unequivocally in place, after leaving the fossiliferous limestones of the Falls of St. Anthony; as well as the place where the last of the sedimentary strata are visible, before being entirely hidden from view under the superincumbent drift.

In the cut of a rivulet which enters the Mississippi, three miles above the Falls, a white loose sandstone is exposed, the same formation (St. Peter's Sandstone, F. 2, c) which forms the lower eighteen feet of the sections at the Falls of St. Anthony. Scattered along the declivities of the bank, are also fragments of the overlying fossiliferous limestone. This is the last exposure of these rocks I was able to discover in ascending the Mississippi. Beyond this, they are lost to view under the drift. For a distance of over sixty miles, by the land route, or nearly eighty by the course of the stream, no rocks were seen unequivocally in place; but in many of the intervening rapids, as, for instance, those above the mouth of Elk River,† there are protruding masses of granitic rocks, which, though they appear like large erratics, resting in the river bed, are probably either in place or not far removed from the parent mass.

At the Osakis Rapids, however, is a beautiful variety of pink granite, and gray, syenitic granite, with veins of a closer grained quartzose granite, well exposed in place, on the east bank of the river, with a bearing of 70° to 80° east of north. Associated with these are subordinate beds of hornblende and greenstone.

Through the kindness of Colonel Fletcher, I obtained a portion of a specimen of native copper, said to have been picked up on the Osakis Rapids. I regret not having been able to see the whole of the original specimen, which was said to weigh ten pounds, as I could then have formed a more correct opinion as to its being a drifted mass, or having originated in veins in the rocks of these rapids. From all

* In some the nacre is entire. Remains of the same kind of shells can also be detected in fragments enclosed in the trap, and so much altered as to be distinguished with difficulty from the surrounding greenstone.

† The Elk River referred to comes in on the east side, beyond Rum River. Another of the same name is laid down on Nicollet's map, higher up, and coming in from the west.

that I was able to gather of the circumstances of its discovery, I am led to believe that it has been transported from a distance.

Mr. Sloan, of Little Rock, informed me, that he had seen a piece of native copper, which was picked up at the Little Falls of Elk River. The same gentleman also described to me a mineral which he had seen, brought from Swan River, supposed to be copper, or some more valuable metal; but I think there is little doubt, from the appearance and character of the ore as described to me, that it was only iron pyrites.

The rocks of this locality are of a character such as have yielded valuable ores in some regions of the old world, but their elevation is but little above high water; and, except over limited tracts, they are entirely hidden from view by deep deposits of drift. This circumstance renders them inaccessible, except at great expense, and indicates no important axes of upheaval, favourable for mining operations.

Seven to eight miles above Osakis Rapids, a short distance below Little Rock, is a higher exposure of crystalline rocks. A ridge of hornblende and syenitic greenstone, with veins of granite, bearing north 70° to 80° east, rises on the east side of the Mississippi to the height of thirty to forty feet; and, a short distance further back, even to the height of sixty to seventy feet. This is, according to our observations, in latitude 45° 39′ 34″, and just opposite to a very extensive plain on the west side of the Mississippi, in the new Winnebago purchase. This plain presented, at the time we visited it, a most animated appearance: several hundred Winnebago Indians were encamped on it, having lately arrived from their former home in Iowa, preparatory to spreading themselves over their new hunting-grounds.

About a mile and a half above Little Rock, a tough, close-grained hornblende rock appears on both sides of the Mississippi, *in situ*, elevated from two to four feet above the water-level, and overlaid by sand and gravel. Similar rocks appear at intervals between Little Rock and Knife Rapids.

From the occurrence of superficial, ferruginous crusts, in the pools of water collected in the hollows of these rocks, it is evident that oxide of iron enters largely into their composition, and exists in a state easily acted upon by the water.

Five or six miles above the mouth of Swan River,* on the Mississippi, is an interesting exposure of gray-coloured mica-slate, charged with large crystals of staurotide. The surfaces of the crystals are, however, rather rough, which impairs their beauty as cabinet specimens. This rock is exposed at intervals for three or four miles.

This mica-slate is succeeded, yet higher up on the Mississippi, by magnesian slates, associated with a tough, close-grained, hornblendic rock. The best exposure of these, is on the rapids, four miles above the mouth of Elk River of Nicollet, where they have a bearing of north 20° east, and lie either nearly vertical, or with a dip of 75° to 80° to the southeast. The slate has quartz veins running through it; there is, however, but little opportunity to investigate its mineral character, for the

* This river is about three miles above our encampment of the night of the 11th of September, at which place two observations were taken, one of *Altair* and one of *Polaris*, which gave for the latitude, 45° 48′ 49″.

banks of the river are quite low, only twelve to fifteen feet above the water at the highest points, and eight to ten of this is soil and drifted materials. This is the last locality where I observed any rocks in place on the Upper Mississippi.* All above, as far as I was able to discover, along my line of route, is overspread with a universal drift of sand, gravel, and erratics, that defy the scrutiny of the geologist to penetrate, but the distant outcrops enable him to conjecture upon what rocky bases it rests.

Section No. 7, shows the succession of formations from the Falls of St. Anthony to the mouth of Crow Wing River.

The country on the east side of the Mississippi, north of the Falls of St. Anthony, and between that place and the mouth of Rum River, is prairie, with oak openings. For about half the distance the growth of timber is very stunted; indeed, along the whole distance we saw no large trees. The dwarfish character of the timber does not appear to depend here upon the sterility of the land: it is true, the soil is siliceous, having been derived, in a measure, from the destruction of the sandstones of F. 2, C; but it is not not deficient in organic matter, and produces better crops than its appearance at first view would indicate.

Approaching Rum River, the oak openings and prairie are interspersed in a manner to remind one forcibly of the ancient parks of European countries.

The width of the Mississippi at its confluence with Rum River, according to a trigonometrical measurement by Colonel Whittlesey, is six hundred and seventy-five feet.

Here there are two benches of land, both of which are very suitable for agricultural purposes. The first is about fifteen feet above the level of the Mississippi; the second, from thirty-five to forty feet. Both appear to be composed, beneath the soil, of drifted sand and gravel. Both have a good soil, but the first is of superior quality; this bench, however, is of less extent than the second.

Beyond Rum River, for about four miles, the face of the country is similar to the above; the soil, however, is *third rate*, sandy and gravelly. Here I noticed that the most stunted trees grow on the more exposed situations. This seems to indicate that the strong winds which often sweep over the extensive prairies of the North, exercise a considerable influence in retarding, and even suppressing, the growth of timber.

The greater part of the distance between Rum River and the next stream flowing into the Mississippi, on the east side, is open prairie.

On the opposite side of this stream,† the soil improves in quality, and the prairie is beautifully interspersed with groves of small timber; the land lying well for cultivation.

The prairies of this portion of the Upper Mississippi are frequented by a small, light, and rather elegant species of ground-squirrel, allied to the *Souslik* or *Spermo-*

* Dr. Norwood, whose route extended several hundred miles farther up the Mississippi, reports, that between this and the Falls of the Pakegomag, a distance of some two hundred and fifty miles, he saw no rocks in place. At that point a ridge of quartzite crosses the valley of the Mississippi.

† This stream is known to the inhabitants by the name of *Elk River*, and is liable to be confounded with a stream of the same name, laid down on Nicollet's map as entering the Mississippi higher up, from the west.

philus of Cuvier, and somewhat longer than the common ground-squirrel of the West.

Twelve miles from Elk River, we passed a lake, on our right, two to two and a half miles in length, and about a mile wide. Its waters are remarkably clear, and the shores are strewn with a great variety of pebbles of quartz, petrosilex, hornstone, chert, granite, greenstone, and porphyry.

Near the road, and about two miles from the Osakis Rapids, there rises out of the prairie a dome-shaped mass of syenitic granite, elevated ten to twelve feet above the level of the plain. This is the eastern extension of the chain of rocks formerly mentioned as crossing the Mississippi at Osakis Rapids. It is worthy of notice here, as being the first rock found *in situ* on the land route from the Falls of St. Anthony to Crow Wing, and because there is here also a marked change in the character of the ground. The prairies are no longer so level as they are south of this exposure. Here may be considered the commencement of those marshy, boggy lands, which, with intervening lakes, ponds, tamerack and cedar swamps, characterize a great portion of the Upper Mississippi and its tributaries, even as far as the northern boundary of the United States. It is true that here and there may be seen limited tracts of good land; but, taken as a whole, it is a poor agricultural country; not to be compared in value to the prairies south of the Falls of St. Anthony, in Wisconsin and Iowa, and the Valley of St. Peter's. This is an important fact, to be borne in mind in case the government should still contemplate purchasing the lands north of the line of the treaty of 1837.

I speak now chiefly of the lands on the east side of the Mississippi; for I had not much opportunity to examine the country lately purchased for the Winnebagoes, on the west side, between Osakis Rapids and Long Prairie River.

Beyond Little Rock, the road passes over an extensive level prairie, with a second rate siliceous soil, and elevated beyond the reach of the high water of the Mississippi. About ten miles beyond Pekushino or Platte River, which heads near Mille-Lacs, we entered upon a flat country, intersected with wet, marshy ground, very difficult to travel over with loaded wagons; after which we passed across a level prairie to Nokay River, a distance of some ten miles. On our right, a mile or two northeast of the Knife Rapids, is a ridge of drift, a hundred and twenty-five feet high, and most probably based upon the extension of the mica-slate, which protrudes in the bed of the river at these Rapids. This is a conspicuous landmark, and affords, from its summit, an extensive prospect in every direction over the surrounding country. It has been selected, on this account, as the burial-place of a celebrated Indian chief, of the Chippewa nation, Hole-in-the-clay; and affords an instance of the predilection of the Indians for commanding positions on which to deposit the remains of those whom they respect, and whose memory they desire to perpetuate.

Crow Wing and Leaf River Lands.—The country which I travelled over between the mouth of Crow Wing and the outlet of Otter Tail Lake into Red River, furnishes little of interest to record. It is, for the most part, flat, especially towards the heads of the streams; the soil is generally poor and sandy, or too wet for cultiva-

tion. A few boulders, here and there projecting above the water-level, in the more rapid parts of the stream, or occasionally in the banks, constitute all that meets the eye of the geologist. These are usually of granite, or some allied crystalline rock. After ascending Leaf River some forty-five or fifty miles, I detected, among the drift composing a ridge of seventy-four feet in elevation, a few fragments of limestone, containing obscure organic forms. These indicate an origin from some calcareous formation to the north or northwest, belonging probably to the age of the Silurian rocks of Europe. They increased in number and size as we approached Otter Tail Lake. The indications on that lake were so abundant, that I was led to believe that the more angular fragments must have their origin at no very distant locality. No ledges could, however, be detected. The lake shore is lined, wherever the banks are high, with heavy beds of erratics, thrown together in indiscriminate confusion, and over which, in windy weather, the waves dash, flinging their spray high into the foliage of the overhanging trees and interlacing vines that fringe the bank, and find root in the scanty soil collected between the water-worn boulders.

The banks of the Crow Wing are seldom over fifteen feet, and usually not more than five to ten feet high. The forest is composed of pine, birch, elm, and oak. The trees are mostly of small size. The largest pines which I observed, were from eighteen inches to two feet in diameter, but they are usually not more than from nine to twelve inches. The best pine forest near the river, is about twenty miles below the confluence of Leaf and Crow Wing, in latitude 46° 20′ 14″, according to our observations. About twenty-three miles up Leaf River, we arrived among groves of pine, which extended some four or five miles along the river. The trees appeared very uniform in size, but were mostly less than a foot through.

The temperature of the water of Crow Wing River, on the 12th of June, at three o'clock P. M., was 67° Fah. The temperature of the air in the shade, was 66°; in the sun, 86°. The temperature of the water of Leaf River, at three P. M., on the 14th of June, was 75° Fah.; of the air in the sun, at the same time, 90°. On the 16th of June, at ten A. M., the temperature of the water of the same stream was 71°. This was only about one mile from Leaf Lake, in which this stream takes its rise. The temperature of the air in the shade, at noon, of the same day, was 77°.

Leaf River has a very circuitous course, for ten miles, through a tamerack swamp, after leaving Leaf Lake. It was with great difficulty that we could find, on this part of the river, ground solid enough to admit of landing. On the night of the 15th, we were obliged to "run" till nine o'clock, before we found a bank sufficiently firm and dry to admit of pitching our tent.

The head-waters of Leaf River have a sluggish current, but are nevertheless very clear, and afford some noble specimens of *Planorbis corpulentus* and *Limnea megasomus.*

At half past ten, on the morning of the 16th, we entered Leaf Lake. It is about three and a half miles long, by one mile wide, and is surrounded by low hills of drift. It communicates, by a very narrow channel, through which we had great difficulty in passing our canoes, with a second lake, of which the shores are somewhat lower. From the northwest end, a portage of four to five hundred yards,

over good ground, leads to a third lake, of nearly circular form, with no inlets, and of smaller dimensions, being a mile to a mile and a half in diameter. A portage, of some fifty yards, brought us to a fourth lake, formed of two nearly circular basins, connected by a narrow water communication. These two lakes are nearly on the same level, with a low ridge between them of about fifteen feet in height.

From the southwest end of this fourth lake, a portage, of a mile and a quarter, crosses a gently undulating prairie, to near the northeast end of Otter Tail Lake. This prairie is about eighty feet above the fourth lake, and divides the waters flowing into the Gulf of Mexico from those flowing into Hudson's Bay. It is by far the most habitable country that came under our observation, between Crow Wing and Otter Tail Lake.

Our observation, by *Polaris*, on the 14th of June, gave for the latitude of Leaf River, about forty miles above its mouth, by the meanders of the stream, 46° 30′ 27″. By meridian altitude of the sun, on the 15th, at a station situated seven to eight miles east-northeast of the first of the above lakes, the latitude was found to be 46° 28′ 8″. On the 17th, by meridian altitude of the sun, our encampment, one mile below the northeast end of Otter Tail Lake, was found to be in latitude 46° 24′ 1″.

It appears from these observations, that Otter Tail Lake, as well as the head-waters of Leaf River, are represented, on Nicollet's maps, too far to the north, by from twelve to fifteen miles. The direction of the last fifteen or twenty miles of Leaf River, as well as the position of the four lakes, require considerable alteration. The latter, instead of lying east of the *middle* of Otter Tail Lake, are situated near its northeastern termination, and have a general relative bearing, as they succeed each other, of west-southwest and east-northeast, instead of west, or west by north.

Otter Tail Lake is about twelve miles in length by four wide. The northern portion of it has a bearing nearly north and south, while the southern part lies south-southwest and north-northeast. The soil near the lake is siliceous. The best, which is in the vicinity of the old trading-post, is a tolerably good second-rate soil, supporting a growth of white oak timber. A short distance below the trading-post, in a southeast direction, is a fifth lake, which intervenes between Otter Tail Lake and the fourth lake. In high stages of water, a portage can easily be made into this lake, saving at least half or two-thirds of the distance of the portage between the fourth lake and Otter Tail Lake. The land between the fourth lake and the stream which enters Otter Tail at its northern extremity, is open undulating prairie.

These regions are frequented by a beautiful species of pelican (*Pelecanus trachyrhyncus*), of snow-white colour, with a few jet-black feathers in the wing.

Otter Tail Lake is quite shallow; half a mile from the shore, we found it to be hardly four feet deep. The temperature of the water, on the 18th of June, was 65°, while that of the air in the shade was 64°. The erratic blocks heaped together on the most conspicuous point of the west shore, vary in weight from a few pounds to several tons. The height of the bank measured forty-three feet. It gradually declines toward the lower end of the lake. Pieces of the same fossiliferous limestone observed on the east shore, also occur here, of larger size. During the few days we tarried in this neighbourhood, we had several opportunities of witnessing

the beautiful phenomenon of the *mirage*. An image of the distant horizon was distinctly pictured upon the sky, usually in an inverted position.

The outlet of this lake into Red River of the North, is at its southwestern extremity. The general level of the prairie is thirty-five to forty feet above its surface. On one of the elevated points, commanding the entrance to Red River, on the south, are six conspicuous dome-shaped mounds, bearing northwest and southeast. They appear to be tumuli of the aborigines.

Descent of Red River of the North (*Otter Tail River of the Indians*).—About noon of the 18th of June, 1848, we commenced the descent of Red River. Since so little definite information has hitherto been obtained regarding this stream, it may be interesting to note my observations on its character, and the agricultural capability and physical geography of the adjacent country, along with the few facts obtained on its geology.

Half a mile from the entrance, on the right bank, is a bed of light yellowish gray plastic clay, two and a half to three feet thick. This, I suppose to be a sedimentary deposit, derived from the destruction of the marlites, interstratified with the beds of Silurian limestone, of which so many fragments are found in the vicinity of the lake.

About four miles farther down the river, the stream becomes very circuitous, and expands in width, forming, in the course of the next twenty miles, a series of basins, or small lakes, varying from one to two miles across. The first two of these are nearly circular, and about a mile in diameter; the bearing of the entrance and exit being northeast by east and southwest by west. Their banks are from fifteen to thirty feet high. The second of these is connected, by a bend of the river to the west, with the *third lake*, about a mile long, and half a mile wide. Its lower extremity curves around to the north. On the left bank, erratic blocks are exposed. After coasting around this third lake, we found it had no outlet; we were therefore compelled to pass again into the *second lake*, on the north side of which we discovered a strong current; this directed our canoe-men to the entrance into the *fourth lake*. The latter we found separated from the *third*, by a narrow ridge, of twenty-five to thirty feet, of drift. This *fourth lake* is from half to three-fourths of a mile wide, and has its outlet on the north. On leaving it, the river bears away, first to the southwest and west, and then northwest and north.

Two miles below the fourth lake, we came to slight rapids, with boulders in the stream, and a few rods beyond, ran a short but swift rapid, with low banks of drift, covered with a small growth of oak and birch.

The waters of Red River are here quite clear, so much so that numerous *Cyclas* could be seen distinctly on the bottom. Its temperature, at three P. M., of the 18th of June, was 69·5.

Just below these rapids, we encountered a small party of the Pillager Indians, ascending the stream in quest of fish. After a short interview, we continued our journey, passing some swampy ground, bearing a growth of tamerack, or American larch.

Eight miles below the *fourth lake*, we entered the *fifth*, which is about a mile and a half long, and one mile wide, bearing northwest and southeast. Its outlet

is at the northwest end, which opens almost immediately into the *sixth lake.* This bears at first to the south, and then bends off to the northwest, where the channel of the outlet meanders through a wide expanse of water, filled with rushes and water-lilies. After leaving this, the river sweeps in a bend of a mile to the southwest, into the *seventh lake,* which is bordered by woods of birch and tamerack. The bearing of this lake is south. Half a mile beyond this, is the *eighth lake,* running from northeast to southwest, and supporting, in some places, a growth of wild rice (*Zizania aquatica*). The *ninth lake* is two miles beyond the last. It is a mile long, half a mile wide, and bears about east and west. The land rises here higher than previously, the north bank being upwards of a hundred feet high. The *tenth* and last lake, two miles below this, is one mile and a half long, from northeast to southwest, and half a mile wide.

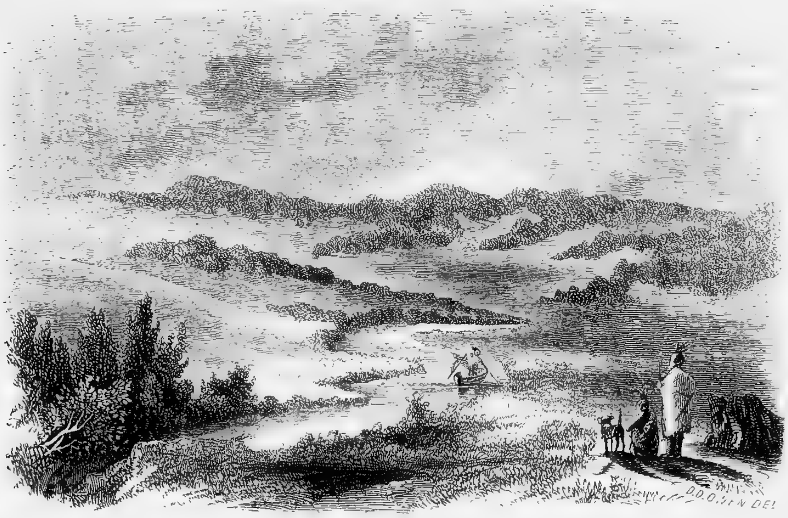
Soon after leaving these lakes, Red River descends in a succession of rapids, some of which are long and swift; one required fifteen minutes to run over it. They are full of erratic blocks of igneous rocks. On the southeast side of the river are banks of drift, eighty to a hundred feet high, supporting a growth of oak, birch, and aspen poplar. From the lakes to these rapids, the course of the stream is at first south or south by east; after which, it turns westwardly, which may be considered its general bearing.

Soon after passing these rapids, about four or five miles below the last lake, the woods on the shore give place to prairie, with groves of dwarfish aspen. Many of these groves having been destroyed by the wild fires sweeping through them, are left as bare, blackened poles, standing so thick upon the ground, as to make it a difficult matter to penetrate among them. The river here takes a southeasterly course, to another succession of small rapids, and then bears away southwest and west.

The prairie is elevated on this part of Red River, thirty to forty feet above the water-level. Four and a half miles beyond the last-mentioned rapids, is another, and a rather difficult one, running south; and about four miles further on, in a southeast course, are again other rapids, with a high sand-bank on the east side. This was about a mile from our encampment of the night of the 19th, which was ascertained to be in latitude 46° 18′ 50″. Here, from some high ground on the right bank, we had an extensive prospect of the surrounding country, which is a fine rolling prairie, extending down to the river bank, with here and there a grove of oak and aspen, and frequented by herds of elk. A high ridge of land could be seen far away to the southeast. The river is from forty to fifty feet wide at this place.

For the distance of six miles more, are alternate rapids and gentle current; the general course of the river being southeast. Here a stream, nearly as large as the branch we were navigating, comes in on the left, which is doubtless the one laid down by Nicollet, as proceeding from a lake lying east of the main stream; but its confluence with Red River is certainly represented on his map too far to the south by twelve or fourteen miles, since it cannot be more than three or four miles farther south than our encampment of the night of the 19th, which was in latitude 46° 18′ 50″.

The country bordering on this part of Red River is quite picturesque. A sloping prairie extends down to the river, crested with beautifully disposed groves of timber, the foliage of which, at the season we were there, was of the freshest and deepest green. The subjoined view represents the features of this landscape.



RED RIVER OF THE NORTH, BELOW OTTER TAIL LAKE.

The river soon winds, in a westerly course, for about four miles, between banks of drift, from fifty to seventy feet high, forming several swift rapids, and again meanders through the same kind of fine, open, rolling prairie, with groves of timber. A number of white granitic boulders are scattered here and there on the elevated swells of the prairie, some of which, in the distance, might be mistaken, in a settled country, for small dwellings. Near the foot of a short rapid, where the river makes a bend to the northwest, I discovered the first ledges of limestone which I saw in place since entering Red River. They might easily be overlooked, since they protruded but slightly from under the sod of the prairie, two to three feet above the bed of the river. The lower layers are a magnesian limestone, of a light buff colour, with brownish stains. The upper layers are composed of a purer calcareous rock, resembling, in lithological appearance, specimens obtained by Dr. Shumard in the drift of the St. Peter's. Both contain impressions of fossils, but these are most abundant in the upper layers. Among them, I recognised an undetermined species of *Delthyris*, an *Orthis* like the *Testudinaria*, a *Leptæna* like the *Sericea*, and a turbinated coral. The fossils are casts, which fact makes it difficult to determine the species positively; but I feel satisfied, that the formation belongs to the Lower Silurian system, of the old continent.

A short distance below this, in running rapids which are usually avoided by a portage, we met with the accident to our canoe, and loss of part of our provisions, as mentioned in the Introduction.

Whilst the men were repairing the hole in our canoe, the clouds cleared away sufficiently to get a series of observations of the sun's altitude, which gave for the mean local time 2 h. 54′ 53·76″, and the estimated latitude 46° 13′ 24″.

This observation, together with those previously obtained at Otter Tail Lake, and between that place and the Great Rapids, also an observation on Polaris, the same evening on which we reached these rapids, all prove that the whole of this portion of Red River is laid down on Nicollet's map too far to the south, by from twelve to fourteen miles. Our observations for longitude make it also rather too far to the east; but as our corps was provided with but one chronometer, I do not feel the same confidence in the correctness of the results obtained for longitude.

So soon as the repairing of the canoe was completed, it was reloaded, and we proceeded on our journey. In a few minutes, we again encountered difficult rapids, and a second time got fast upon the rocks, but succeeded in extricating the canoe without its sustaining material injury. The course of the river at these rapids was northwest, then west, and then southwest. Four miles from this, we passed, on the right, the mouth of a stream, coming from the chain of lakes at the northwest, to which Mr. Nicollet has given the names of various distinguished scientific gentlemen. Many of these lakes, however, are known to the Indians by other names, which it would, perhaps, have been better to adopt, and which it is probable they will ultimately retain. This stream is about half the size of the main branch, being from fifteen to twenty feet wide.

Red River makes here several sudden bends, first to the southeast, then southwest, west, and northwest; the general course being, however, southwest. On the left side is a beautiful undulating prairie, dotted with groves of small oaks, throwing their long shadows athwart the prairie as the fleeting evening clouds coursed through the air. The rural beauty of this part of the Red River country is almost equal to that of the most attractive spots in Iowa.

Boulders of crystalline rocks, and large fragments of limestone, are scattered over the prairie. The soil is good, and is no doubt calcareous, at least where the limestone reaches near to the surface.

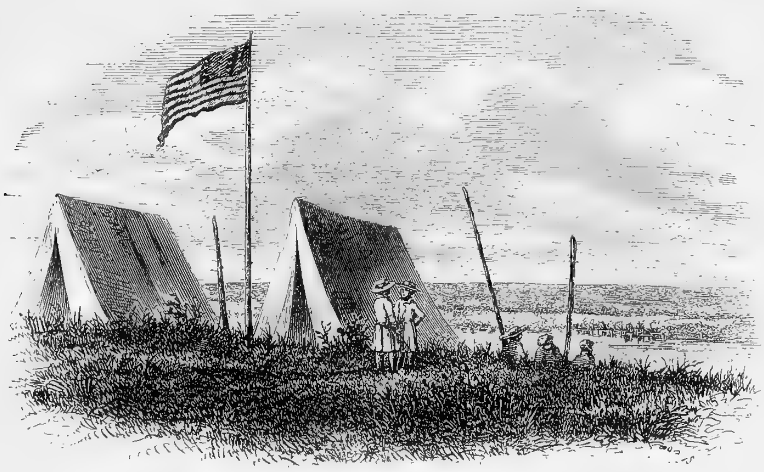
After passing a bank on the left about seventy-five feet high, our course was from south to southeast for a couple of miles, or more, when we came to two more rapids, about a quarter of a mile apart.

Towards the top of a bank, about seventy feet in height, two or three miles lower down, but nearly on the same parallel of latitude as the Grand Rapids, I found fragments of limestone similar to those obtained at the head of those rapids, and, along with them, fragments of a fissile marlite, which cannot be far out of place, and which, therefore, appears to be an associate of these same limestones.

The general course of the river below this, is southwest by west, but it forms numerous bends to the southeast, south, southwest, and northwest. Within the next mile and a half we passed two more rapids. These were the last which we encountered for a distance of some two hundred and fifty miles.

Red River, in making its great south bend, meanders through a boundless prairie, destitute of timber, which gradually declines in elevation, until at length it forms one vast plain, level as a floor, and elevated only about one and a half to two feet above the water at its ordinary stage in June. This south bend lies in latitude 46° 9′, that is, from nine to ten miles farther north than it appears on Nicollet's map.

A faint idea of the appearance of this portion of the country may be obtained from a sketch which I took at our encampment of the night of the 21st of June,



GREAT SAVANNA, RED RIVER OF THE NORTH.

about one hundred and ten miles below Otter Tail Lake. Nothing, however, but personal observation can convey to the mind the singular effect produced by this dead, level plain. The line of the horizon is so perfectly straight, that it might almost serve the purpose of astronomical observations for determining the altitude of the heavenly bodies. While standing on this Great Savanna, straining the eyes in quest of some object more prominent than a blade of grass, it occurred to me that there is probably no spot on the globe more suitable than this, on which to measure a degree of latitude.

Red River makes a greater sweep to the west than is represented on the maps, since it is only after a tortuous course of twenty to thirty miles, with but little deviation in latitude, that it bears away to the north, winding, however, in long sweeps and curves, and often almost reversing its course, in its endeavours to find a channel through this boundless plain. Between the South Bend and Pembina, during each day's journey, we averaged by the course of the stream, thirty-five to forty miles, making in the same time only about ten miles of northing. This will convey some idea of the winding of this stream over nearly five degrees of latitude.

A few general remarks will suffice to record our observations from this point to the settlements of Red River, since these plains extend the whole distance, interrupted only by narrow belts of timber along some of the water-courses, and give a monotonous sameness to the whole face of the country.

The descent of the streams watering these plains is effected more by an excavation into the alluvial deposits, than by any depression of the country.

The first grove of timber, after rounding the South Bend, is in latitude 46° 12′ 40″, where the banks are about fifteen feet above the water-level. In latitude 46° 23′ 30″, a belt of timber sets in, and continues, with some interruption, along the banks of Red River, on one side or the other, to Pembina. These groves are composed

chiefly of oak, elm, and ash. The low banks support only a growth of willows and alders.

To latitude 46° 23′, the waters of Red River continue comparatively clear, beyond this they gradually become more turbid, as the stream cuts deeper into the stiff clay, which forms the substratum for three hundred miles, until, finally, they appear quite milky, from the suspended particles of argillaceous matter.

Boulders are not visible in the bed of the river, after leaving the rapids, for a distance of sixty or seventy miles. About twenty-five or thirty miles, after rounding the South Bend, in latitude 46° 20′, a few again make their appearance in the bank and bed of the stream. Several of those observed in latitude 46° 30′ 30″, and from this point to 47° 30′, are ground flat, grooved, and even planished on one or more sides, either by the grating of the ice, which accumulates each winter in vast piles on this stream, or by some more general action during the drift period.

The air along Red River, from the mouth of the Psihu to the settlements, is scented, during the months of June and July, with a delightful perfume arising from the wild roses, which form a thick shrubbery along its banks.

The current, after passing the rapids, is moderate, running about a mile and a half an hour. The temperature of the water, at two o'clock P. M., on the 23d of June, was 69° F., whilst the temperature of the air in the sun was 80°. On the 24th of June, the temperature of the water was 72°, while that of the air in the sun was at the same time 93°.

In latitude 46° 41′ 12″, the level of the prairie, above the river, was found to be thirty feet. Putting the descent of the river, after rounding the South Bend, at three and a half inches per mile, which is probably very near the truth, this thirty feet is due entirely to the cutting down of the bank, and not to any elevation of the land.

The tributaries of Red River are few and of small size: Psihu River is only eight or ten yards wide at its mouth; the Shayenne, the principal tributary on the west side, about double that width; Buffalo River is about the same width; Elm River hardly deserves the name of a river, being only about six yards wide. Wild Rice River is only about double that width; Goose River hardly so much; and Sandhill River still less. The Red Fork is, in fact, the only tributary of any size that flows into Red River between the South Bend and Pembina River. Though the relative position of these streams is tolerably well preserved on Nicollet's map, still the location of the mouths of some of them requires some correction. The Shayenne, at its junction with Red River, is, according to my observations, in latitude 47° 1′, instead of 46° 59′ 30″; that of Elm River in 47° 17′, instead of 47° 9′; that of Wild Rice in 47° 18′ 30″, instead of 47° 13′; that of Goose River in 47° 25′, instead of 47° 32′; that of Sandhill in 47° 26′, instead of 47° 33′. These positions were determined not only from observations for latitude near their mouths, but were corroborated by the observed courses, time, and distances.

The *Red Fork* of Red River, which flows from Red Lake, is a considerable stream, being about a hundred feet wide, whilst the width of the East branch is about one hundred and twenty feet. The former is the stream to which the name of *Red River* properly belongs. The stream which we navigated is known to the Indians

by the name of Otter Tail River. The colour of the waters of Red River proper, also shows the origin of the name; they are of a reddish-brown cast, and contrast strongly with the whitish, milky appearance of the stream coming from Otter Tail Lake, and which henceforth assumes a darker hue. The distance by water from Otter Tail Lake to the Red Fork, we estimated at three hundred and seventy to three hundred and eighty miles.

The soil adjacent to the main stream, from latitude 46° 30′ to Pembina, is of an argillaceous character. Near its confluence with the Red Fork, in latitude 47° 55′, it is so stiff, that in drying, it cracks, and bakes together. It seems to be congenial to the ash, which tree attains here a large size. Cottonwood timber also makes its appearance in this vicinity.

In latitude 47° 54′, we passed on the right a spring, having a saline taste. Its water gave, with nitrate of silver, a precipitate not wholly soluble in nitric acid, and partially soluble in ammonia, indicating the presence of chlorides.

Below the mouth of the Red Fork, we observed several strong chalybeate springs, oozing from the clay-banks. Here also is found evidence of the power of the ice on this river during the winter season. Fifteen, eighteen, and even twenty feet above the level of the river, in July, we observed the trees on the brink of the river, either barked or deeply cut into, and even entirely severed across.

Unios are very abundant in this part of Red River. The most common are *Unio quadrulus, U. alatus, U. crassus, U. plicatus,* and *U. gibbosus.*

In latitude 48° 23′, on the afternoon of the 2d of July, the temperature of the water was found to be 69°, while that of the air at the same time, in the shade, was 64°. In latitude 48° 37′, on the 4th of July, the temperature of the water was 70°, at three P. M.; that of the air was 78°, in the shade, and in the sunshine, 86°. The stream is here about three hundred feet wide.

The mouth of Turtle River is, according to our observations, in latitude 48° 9′; that of Big Saline, in 48° 23′ 25″; and that of Two River, in 48° 50′.

In the forenoon of the 5th of July, we discovered signs of civilization,—the trees chopped with the axe. At noon of the same day, we descried, from an elevated position, a log habitation, and at two in the afternoon, reached the mouth of Pembina River, where Mr. Sibley's American Trading-Post, in charge of Mr. Kittson, is situated. This is about two miles south of the United States line, being in latitude 48° 58′, just at the head of the settlements on Red River, which extend for about sixty miles below.

The total distance from Otter Tail Lake to the mouth of Pembina River, by the course of the stream, was estimated at five hundred and twenty-five miles.

Except near the Grand Rapids, no rocks are to be seen *in situ* in the whole of this distance. For more than four hundred miles of the latter part of our route, the soil is underlaid by a stiff, light gray, or ash-coloured clay, which extends beneath the level of the water. Occasionally, a few fragments of limestone, similar to that which we found in place at the Rapids, were discovered among the erratics. Both geologically and physically, it is a country of great sameness and flatness, without the least indication of its containing minerals of any value, except salt, which may be crystallized out of the saline springs. The same remark will apply

to all that portion of the Chippewa Land District watered by Red River and its tributaries.

On reaching Pembina, and making inquiries of the people relative to the adjacent country, I found the opinion prevalent that coal and other valuable minerals exist in the Pembina Mountain, situated to the west, high up on the Pembina River. I determined to occupy the few days required to make the necessary preparation for our return route by the Lake of the Woods, in visiting that mountain, distant a day's journey from Pembina; both for the purpose of determining its geological formation and elevation, and also to ascertain whether it is north of the forty-ninth parallel of latitude, in the territory of the Hudson's Bay Company, or south of it, within the boundary of the United States; a point not yet ascertained by any observers. By the assistance of Mr. James M'Dermott, I succeeded in engaging a guide and a conveyance. This latter consisted of an equipage somewhat novel to me, a real Canadian-French, single-horse cart, made entirely of wood. The segments of the wheels are held together solely by the spokes, wooden pins, and wedges. When they exhibit any signs of parting, they are spliced on either side by pieces of wood, and wound round by withes of raw hide; or they receive a complete tire of the latter material. Raw hide is also used to harness the horse to the cart.

With this equipment, Dr. Litton and myself started, on the morning of the 7th, leaving Mr. Evans to proceed to the colony at the mouth of the Assiniboin, there to make preparation for our return route by the Lake of the Woods; for that, we were told, was the only place on Red River, where we could procure the necessary stores, as Mr. Kittson, to whom Mr. Sibley had kindly furnished us with a letter of introduction, had gone to the States with a supply of furs. After a hot and fatiguing ride over the plains, we arrived, an hour after sunset, at the foot of Pembina Mountain. In the twilight, as we stood at our encampment on the plain, it looked as if it might be three hundred feet or more in height; but in the morning, by broad daylight, it seemed less. When I came to measure it, I was somewhat surprised that it did not exceed two hundred and ten feet. I observed on this, as on many other occasions, that a hill rising out of a level plain, appears higher than it really is, especially when, as in this case, the trees on its flanks and summit are of small growth. Pembina Mountain is, in fact, no mountain at all, nor yet a hill. It is a terrace of table-land—the ancient shore of a great body of water, that once filled the whole of the Red River Valley. On its summit it is quite level, and extends so, for about five miles westward, to another terrace, the summit of which I was told is level with the great buffalo plains that stretch away towards the Missouri, the hunting-grounds of the Sioux and the half-breed population of Red River.

Instead of being composed of ledges of rock, as I was led to suppose, it is a mass of incoherent sand, gravel, and shingle, so entirely destitute of cement, that with the hand alone a hole several feet deep may be excavated in a few minutes. The Pembina River has cut through this material a deep, narrow valley, but little elevated above the adjacent plain. Along its banks are precipices of sand, surmounted by gravel and a few boulders. I was told that it was impossible to ascend these banks. So loose is the deposit, that, no sooner is an ascent attempted, than the

stones, fifty or a hundred feet above, are detached, and come tumbling down at such an alarming rate, that the climber is glad to make his escape.

If any coal was ever found in this deposit, it must have been small pieces washed in by the same force which brought the pebbles and shingle; for certainly there is no regular bed of coal in the sections which I had an opportunity of inspecting, and there is every reason to believe, that the whole terrace is composed of similar materials, none of which possess the characters of the intercalated beds of a coal formation.

As for the ores said to have been found there, I suspect they were only pieces of pyrites and mica mixed with the gravel and sand.

Three observations were taken for latitude at the base of the terrace, near where the Pembina River emerges into the plain,—one of Polaris, one for the meridian altitude of Altair, and one for the meridian altitude of the sun. The mean of these gives for the latitude of the place, 48° 54′ 36″. The mean of two observations for longitude, gave 97° 50′ 30″; but this is probably some minutes too far to the west, as there appeared to be a slight change in the rate of the chronometer, from the land-carriage over the prairie.

The Pembina Mountain is at least five miles within the limits of the United States, that is, that part of it where the Pembina River issues from it into the plain; but the terrace of land, of which it is only a part, stretches away to the north beyond the parallel of 49°, as well as south, on the opposite side of the river. Indeed, I believe it could be traced over a considerable district of country, perhaps to the high land near the head of Shienne and Devil's Lake.

On the prairie, about half way between Red River and Pembina Mountain, an observation was taken for latitude, by meridian altitude of the sun, which gave 48° 59′ 44″; also near the Pembina River, on our return, about twelve miles from Red River, by Polaris, which gave 48° 59′ 15″. Before leaving Red River for Pembina Mountain, and also on our return, several observations were taken for latitude, both of the sun and stars, close to Mr. James M'Dermott's Trading-House, and about three-fourths of a mile north of the spot where we were told Major Long had planted a post,* marking the limits of the United States on the parallel of 49°. Five observations in all were taken, but those by Polaris are probably the nearest correct; one of these, on the night of the 6th of July, gave the latitude 49° 1′ 13″; one, on the night of the 9th of July, gave 49° 1′ 12″; and one, the same night, by meridian altitude of Altair, gave 49° 0′ 22″.

From inquiries which I made, while in the colony, I learned that the boundary of the territory of the Hudson's Bay Company does not follow the parallel of the 49th degree of latitude, but runs from where that line crosses Red River, to a mountain lying to the north-northwest, called by the Indians *Ne-pà-que-win.* The country south of that line, including the so-called Pembina Mountain, formerly belonged to the Stone Indians, who, some fifty or a hundred years since, left the country, and gave it, until they should return, as a hunting-ground, to the *O-jib-ways*, or Chippewa Indians. This tribe of Stone Indians never again returned to reclaim it; they

* This post, we were told, had been removed and burnt, some years since, by a party of Indians, who encamped near the spot.

were exterminated by the small-pox; and the land remained in the possession of the Chippewas, until the Missouri Indians made an incursion into the country, and had several battles with them; after which, the Chippewas left the country, with the exception of ten or twelve families.

On my way from Mr. M'Dermott's, by the river, to the colony, I discovered, not far from a salt spring, loose slabs of limestone, much of the same appearance and composition as those found on the Rapids. On splitting these open, I disclosed an *Orthis*, like the *O. planumbona*, a *Leptena* (species undetermined), and casts of discoidal bodies, which may be the impressions of Orbiculas. The size and angular form of these slabs indicate that they are not far out of place. The mud on the brink of the river looks, too, like decomposed marlite, such as is often associated with the shell-beds of F. 3, of Wisconsin. The same kind of limestone projects from several points of the shore, near some rapids, a few miles further down the stream.

At the top of the left bank of the Assiniboin, close to its mouth, I found beneath the soil some large slabs of limestone, similar to those formerly discovered above the Great Rapids of Red River; but, on closer inspection, it was evident that they were not in place, but had probably served as an underpinning to some house which formerly stood there. I could not learn that there was any quarry in the vicinity whence they could have been brought, but I afterwards observed many large slabs, of the same kind of limestone, about ten miles below, on the immediate bank of Red River, evidently not far out of place. I have no doubt that they were brought from that locality, which is the nearest spot I could find convenient for transportation to the Assiniboin, where limestone fit for such purposes could be procured.

The mean of five observations, at Upper Fort Garry, at the mouth of the Assiniboin, for latitude, three by meridian altitude of the sun, and two by Polaris, gave for the latitude, 49° 53′ 24″. Mr. Calhoun, who was attached to Major Long's expedition, in 1823, made it 49° 53′ 35″; but, according to a record in the possession of one of the officers of the Fort, Le Froy placed it in latitude 49° 58′.

As the preparations for the further prosecution of our journey could not be completed for some days after our return from the Pembina Mountain, I took advantage of this time to drop down to Lower Fort Garry, for the purpose of making some further geological investigations, in the hope of collecting additional evidence of the age of the limestone of Red River.

Some eight to ten miles below the mouth of the Assiniboin, the debris of calcareous rocks are seen on the shore in abundance; also at various points below this, especially where there are some slight rapids. There can be little doubt that the formation from which they are derived, forms the basis of a large portion of the prairie country of Red River.

About twenty miles below the mouth of the Assiniboin, near Lower Fort Garry, solid ledges of limestone are exposed, of a light buff colour, sometimes mottled, spotted, or banded with light brown. Immediately opposite the Fort, a considerable amount of rock has been quarried, and used in the construction of the building. In these beds, I succeeded in finding several well-defined and characteristic fossils, sufficient to establish, without the least doubt, the age of the Red River limestones.

They are, *Favosites basaltica; Coscinopora sulcata;* hemispherical masses of *Syringopora; Chætetes lycoperdon;* a *Conularia;* a small, beautiful undetermined species of *Pleurorhynchus; Ormoceras Brongniarti; Pleurotomaria lenticularis*(?); *Leptæna alternata; Leptæna plano-convexa*(?); *Calymene senaria;* and several specimens of the shield of *Illænus crassicauda.* Many of these are identically the same fossils which occur in the lower part of F. 3, in Wisconsin and Iowa, in the blue limestones of Indiana, Ohio, Kentucky, and Tennessee, and also in the Lower Silurian of Europe. The *Coscinopora* is precisely the same as the coral which is particularly characteristic of the lower beds of the Upper Magnesian Limestone of Wisconsin. The specimens of *Favosites basaltica* cannot be distinguished from those which abound in the Upper Magnesian Limestones of Wisconsin and Iowa, and the Lower Coralline beds of the Falls of the Ohio. It is also worthy of note that these limestones of Red River, like their equivalents in Iowa and Wisconsin, are highly magnesian, containing from seventeen to forty per cent. of the carbonate of that alkaline earth.*

Being curious to know something of the climate of this part of Red River, I made many inquiries, relative to this subject, of the inhabitants; all of whom confirmed the previous idea I had received of the severity of their winters. I am happy, however, to be able to furnish something more definite, which will be interesting to the meteorologist. For the last two years a regular meteorological journal had been kept at the Lower Fort, by order of the British War Department, under the superintendence of the Hon. Captain Moody, of the corps of Sappers and Miners. That gentleman was so kind as to permit me to look over it, and, indeed, to make an abstract, and to copy a portion of it, for the months of January and February of 1847, and June and July, 1848.

The coldest weather which was known during the years 1847 and '48, was on the night of January 20, 1847, when the mercury froze quite solid. On that night the spirit thermometer indicated, at the Lower Fort, —47°; at the Upper Fort, —48°. To test the severity of the cold, some of the officers poured quicksilver into their

* Two analyses, which Dr. Shumard made in my laboratory, and under my direction, yielded respectively as follows:

Compact limestone from Red River, containing *Leptæna*:—

Carbonate of lime,	53·7
Carbonate of magnesia,	40·5
Insoluble matter,	·8
Alumina, oxide of iron, and manganese,	4·
Water and loss,	1·
	100·

Spotted and banded limestone from Red River, containing *Coscinopora*:—

Carbonate of lime,	78·1
Carbonate of magnesia,	17·8
Insoluble matter,	1·
Alumina, oxide of iron, and manganese,	1·4
Water and loss,	1·7
	100·

bullet-moulds and placed them out of doors. Their contents froze in fifteen or twenty minutes, and became solid bullets, that could be, and I believe were, shot out of a fowling-piece. On the same night, Mr. Smithhurst, in charge of the settlement of Cree Indians, twenty-six miles below the Lower Fort, placed some mercury in the open air in a spoon. In twenty minutes it was frozen, and did not liquefy for several minutes after it was brought into a room with a fire in it. Captain Moody informed me, that several times when their thermometer indicated —40°, —41°, or —42°, the mercury was not frozen solid, but only turned of a lighter colour, or frosted appearance. I was told that on going out of doors in weather of this kind, it had an effect on the breathing somewhat similar to that produced by wading into cold water; but since it is usually very calm when the thermometer is so low, the cold is not felt so much as when the mercury is higher, with a breeze.

The mean temperature for the month of January, 1847,—observations taken at 9 A. M., 3 P. M., and 9 P. M.,—was —12½°. During twenty-two consecutive days of this time, from the 5th to the 26th inclusive, the mercury never once rose to zero; the average of the sixty-six observations, during this period, gave twenty and a half degrees below zero as the average temperature. The highest point reached by the mercury, during the month, was 30°; the lowest, —48°; giving a range of seventy-eight degrees.

From the 17th of June to the 17th of July, 1848, inclusive, the mean temperature was 69°. The warmest day was July 17th, when the mercury stood at 96°; the coolest was July 2d, which was 48°—giving a range, for the month, of forty-eight degrees. The range between the coldest day in January, —48°, and the hottest day in July, 96°, was *one hundred and forty-four degrees.*

The summers are usually short; even in the latter weeks of March, and early in November, the thermometer often falls to several degrees below zero. The winter of 1847–8 was regarded as unusually mild, but even then it sunk to *forty* below zero.

The houses in this country are usually built of squared logs, the interstices being well filled with clay, and the whole whitewashed, and sometimes roughcast. The roofs are almost universally thatched with straw. Some of these houses present a very neat appearance.

The soil is of an argillaceous character, well adapted to the growth of wheat, barley, oats, beans, peas, and potatoes; but the summers are often so dry that the crops suffer much on that account. The grain is ground by windmills, which form picturesque and conspicuous objects in the landscape of the plains surrounding the settlement.

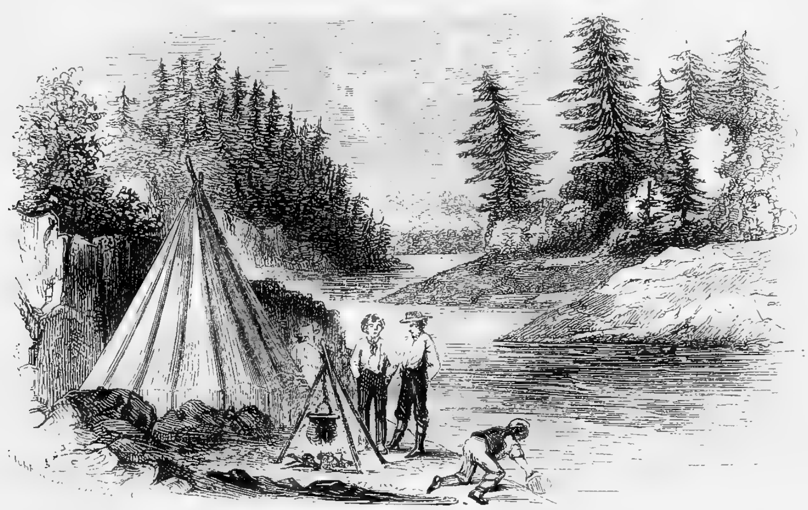
Beyond the settlements of Red River, no opportunity is afforded on that stream for making further observations on the rock formations of the country. A mile or two below the Cree Village, the river enters a tract of low land, and then meanders for more than twenty miles through a morass, before it finally disembogues into Lake Winnipeg. On the south shore of that lake, however, I again had an opportunity of inspecting fossiliferous limestones *in situ.* At the two localities where I succeeded in obtaining a view of them, they were very much disturbed, dipping either at a high angle, or, standing vertically. On Poplar Point, they are quite thin-bedded, and contain besides small *Entrochites*, large varieties of *Endoceras.* In a

small bay, near Big Swamp Point, the limestone is seen jutting out beneath heavy, loose masses of crystalline rocks, some of which would weigh hundreds of tons. The surfaces of many of the limestone slabs at this locality are crowded with well-preserved specimens of the characteristic fossil, *Leptæna alternata.*

Before leaving Fort Garry, I obtained a fine specimen of chain coral (*Catenipora escharoides*), which was said to have been obtained either on the shores of Lake Winnipeg, or in the vicinity. Thus, it appears that limestones of the age of the Lower and perhaps Upper Silurian rocks of England, extend as far north as the south shore of Lake Winnipeg, retaining not only the palæontological features which they possess in Wisconsin and Iowa, but much the same lithological character also. There is reason to believe, too, that these calcareous beds of F. 3, abut on the granites and syenites of this region of country, without the intervention of F. 1 and F. 2; since no rocks referable to these latter formations were observed there in the few miles between Big Swamp Point and the entrance of Winnipeg River, where the crystalline rocks are unequivocally in place.

However, such might very well exist, and be easily overlooked, or hidden from view by the water and immense masses of erratics that line the shores, and rest upon the upturned edges of the sedimentary beds.

I am led to believe, from information obtained at Fort Alexander, that the same limestone which we found in place at Poplar and Big Swamp Points, will be found extending at least as far north as Rocky Point, and Isle La Biche, or Elk Island.



DECHARGE DE LA CAVE.

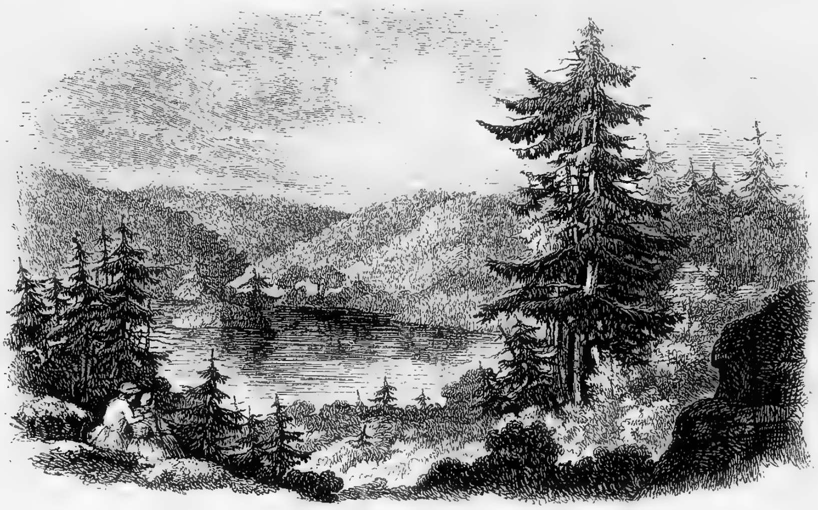
As many geological details of the country immediately bordering on the northern limits of the United States, have been given in the Narrative of Major Long's Expedition, published in 1824; and, as the geology of Northern Minnesota will be treated of more particularly in Dr. Norwood's Report, I shall, in order to avoid unnecessarily increasing the bulk of this work, conclude this section with only a few general remarks touching one or two important features of that country along my immediate route of travel, in returning from the Lake of the Woods to Lake Superior, in 1848.

The great geological formations of that part of the District, are crystalline and metamorphic schists, penetrated by granitic and syenitic ranges, the general bearing of which is northeast and southwest, deviating in a slight southerly curve as they reach the Mississippi and the St. Peter's, in the southern part of Minnesota. The rocks composing these ranges have, for the most part, a moderate elevation above the general drainage of the country, though somewhat greater than through most parts of the interior of the District. An idea of the features of the country may be obtained from the sketch at the head of the previous paragraph, taken at a locality known to the Canadian voyageurs as the Decharge de la Cave.

The most elevated portion of the formation lies along the chain of lakes situated between longitudes 91° and 92°, where the summits of the hills are, at a few points, several hundred feet above the adjacent lakes.

Towards the extreme northern boundary of the United States, amidst the numerous islands of the Lake of the Woods, semi-crystalline, magnesian slates prevail, assuming, locally, gray and silvery white tints, similar in composition to some of the slates of the Valley of the Levantine, near Mount St. Gothard, in Switzerland. The occasional protrusions of granite are frequently reticulated by a complete net-work of veins of quartz, felspar, and graphic granite, and the former mineral often traverses the adjacent slates.

The most elevated range which we passed over, was on the trail leading from the Prairie Portage to Cold-Water Lake. In view of that lake, the scenery is abrupt and exceedingly romantic, as may be observed from the subjoined cut.



GRANITIC AND SYENITIC RANGES, COLD-WATER LAKE.

This view was taken from our camping-ground, at the head of the valley, looking over the precipitous descent towards the northeast, and rivets the attention the more, since it appears in striking contrast to the flat bogs and marshes which we had just passed over, on the Savanna Portage, a few miles back, and the multitude of low islands we had previously threaded before entering the Savanna River, on the northern slope of the same water-shed.

The waters of this lake are remarkably cold—below 40° of Fahrenheit's thermometer. Its chilling effects on the superincumbent atmosphere, condenses its moisture into fine spray, which, floating in the rays of a setting sun, as we viewed it in the evening, presented the most brilliant rainbows, such as are frequently to be observed throwing their prismatic arches over the precipice of some foaming cascade.

During the night of the 4th of August, when we encamped on the spot from which the drawing was taken, water was frozen in a tin cup, and the ground was covered with frost in the morning.

Our pilot, an old, experienced voyageur, who had made the trip from the Assiniboin Settlement to Lake Superior some ten or a dozen times, stated that he had never passed this place, even in midsummer, without experiencing frost.

From Cold-Water Lake to Lake Superior, the descent is much shorter and more abrupt than on the northwest, towards Lake Winnipeg.

M'KAY'S MOUNTAIN, FROM FORT WILLIAM.

After making the last portage but one, on the route to Thunder Bay, on Lake Superior, the sudden passage from the metamorphic schists to the slates and conglomerates of Lake Superior, is marked by precipitous falls, well illustrated by the frontispiece. The Falls of Kakkabika, almost a counterpart of those on Pigeon River, indicate a corresponding change along the face of the southern bearing of the northern extension of this ancient system of crystalline schists on the Kaministiquia; indeed, this geological transition is uniformly accompanied by analogous

scenery on all the principal streams flowing into the northwestern portion of Lake Superior.

In the further descent down these streams, the great slate system of Lake Superior, indicated on the map by a neutral tint, with its associate traps, appears in the form of abrupt precipices, of many hundred feet, facing usually the east and northeast on the main shore, and the northwest on the adjacent islands. This geological feature is well illustrated by the contour of M'Kay's Mountain, as it looms in the distance from the mouth of the Kaministiquia.

CHAPTER V.

FORMATIONS OF LAKE SUPERIOR.

As the geology of this portion of the District is treated in detail in the accompanying Report of Assistant-Geologist, Dr. Norwood, who was specially charged with the examination of the northern and part of the southern shore of Lake Superior, and as many particulars are also given in the appended observations by Colonel Whittlesey, as head of the sub-corps which examined the south shore, between the Michigan line and the Bois Brulé, I deem it unnecessary, under this head, to subdivide my own remarks as in the previous chapter; and shall confine them chiefly to a brie review of the much-contested question of

THE AGE OF THE RED SANDSTONES OF LAKE SUPERIOR.

Geologists of experience have, until this time, differed widely as to the period to which these sandstones should be assigned. The difficulty rested chiefly in this, that it had been hitherto impossible, in the solution of the question, to apply any decisive palæontological test. The most diligent search has not yet brought to light, in these sandstones, any fossils, except a few impressions, which are doubtless *Fucoides*, or fossil sea-weeds. (Tab. I., C, and Tab. II., Figs. 1 and 2.) And this family of marine plants, common to various formations, have a specific character too indefinite to permit their being regarded as trustworthy guides in the identification of strata.

Some geologists have been of opinion, that these sandstones are of the age of the Old Red or Devonian period; some, that they belong to the Upper Silurian System, above the Niagara Group of New York; some, again, that they are the equivalent of the Potsdam Sandstone of the New York Series. Others have stoutly denied this, and have concluded, that they are to be assigned to a period subsequent to the carboniferous; to the Triasic; in other words, to the New Red Sandstone Formation.*

* The late lamented Dr. Houghton, to whose careful examinations of the Lake Superior District, science and the Department were indebted for so much valuable information, seems, as late as 1843 (two years before his death), to have held, as to the red sandstones on the south shore, west of Keweenaw Point, to

If, in the absence of conclusive palæontological evidence, the test of lithological character alone be applied, it must be admitted to favour the view, that they are of the same age as the red sandstones of Virginia, Maryland, New Jersey, Connecticut, and Nova Scotia. Specimens of the red sandstones of the south shore of Lake Superior (in Wisconsin), including the buff beds associated with them, cannot be distinguished from specimens in my collection, procured from the quarries of Seneca Creek, in Maryland, of Acquia Creek, in Virginia, and of Little Falls, in New Jersey; all of which are generally admitted to be of cotemporaneous origin.*

Some of the results from chemical analysis seem also to favour the same hypothesis. Taken as a whole (though with exceptions†), the sandstones of Lake Superior contain a considerable percentage of alumina, ranging, sometimes, as high as twenty per cent.; while of silica there is often less than fifty per cent. Their peculiar red colour is due to the presence of a large proportion of peroxide of iron,

this latter opinion. In the report of the proceedings of the Association of American Geologists for that year, we find the following:

"Dr. Houghton said, that the sandstone of Lake Superior, lying east from Keweenaw Bay, dips, at a moderate angle, to the south, or a little east of south, and passes under a lime-rock, which he considers to be the equivalent of the Trenton lime-rock of New York; while those conglomerates and sand-rocks lying westerly from Keweenaw Point, and flanking the trap on the north, dip to the north, mostly at a high angle. *These last-mentioned rocks are probably cotemporaneous with the New Red,* and were doubtless deposits during the long interval that marked the upheaval of the trap," &c.

I have sought for, but not met with, any subsequent statement of Dr. Houghton, reversing this opinion.

My own first impressions, during the explorations of 1847, favoured the same view of the case. In my provisional Report, of 1848, while asserting that "it is impossible, at present, to decide between these conflicting opinions," I added: "Judging from lithological and mineralogical character, there certainly is strong presumptive evidence, that they were deposited subsequent to the carboniferous era."

It is only after a careful review of all the facts bearing on this question, collected by myself and other members of the corps, that I have finally reached the conclusions given in this chapter. I doubt not, that, had Dr. Houghton's valuable life been prolonged, he also, after examining the problem in all its bearings, would have seen cause to give the weight of his authority to the opinion, that the red sandstones in question are of Lower Silurian date.

* It was formerly the admitted doctrine, that these sandstones are of New Red date, the equivalent of the *Grès de Vosges* of Alsace, the *Bunter Sandstein* of Germany, and the Triasic System of recent writers. However, the opinion has been advanced by some, that the lower beds of red sandstone running through the older States, are of a date anterior to the coal; perhaps, Upper Silurian; perhaps, like the sandstone of Lake Superior, which, in aspect and composition they so much resemble, Lower Silurian. With so much uncertainty still hanging over the date of a formation so long submitted to the oldest and most experienced geologists of the Union, it is little surprising that a series of rocks in the remote West, similar to the others, alike in their appearance, and in the absence of acknowledged characteristics, should have caused doubt and variance of opinion, before, at last, after thorough and minute exploration, their true age was satisfactorily explained.

† As shown, for example, in the following analysis of red sandstone from Madeline Island, one of the Apostle Group, off the south shore of Lake Superior:

Insoluble silicates,	93·5
Iron and alumina,	3·9
Carbonate of lime,	1·0
Carbonate of magnesia,	a trace.
Loss,	1·6
	100·00

with a much smaller proportion of protoxide. Both taken together, range from five to twenty per cent. In all this, these rocks resemble the red sandstones of the older States, and differ essentially from the more common varieties of sandstone, appertaining, on the Mississippi and its tributaries, to F. 1, the equivalent of the Potsdam Sandstone of New York. This Lower Silurian rock, taking its general mass, is of a white or buff colour, and is a siliceous (quartzose), not an argillaceous or ferruginous sandstone. With the exception of subordinate beds, of red colour, usually in the immediate vicinity of igneous ranges, it commonly contains ninety-two per cent. and upwards of silica; while of alumina and oxide of iron, taken together, it has seldom more than three per cent.

In determining, however, the synchronism of two or more formations, it is, as every geologist knows, wholly unsafe to rely upon lithological appearance and chemical composition, except as corroborating indications. Equivalent formations in distant countries, or even at comparatively short distances, vary greatly in this respect. Indeed, beds of strictly cotemporaneous origin (as indicated by the identity of their fossil remains), may, at one locality, be true limestone, at another pure sandstone.

The test of superposition, on the contrary, is satisfactory and conclusive, provided it be unequivocally obtained. How far Dr. Norwood, who was specially charged with this investigation, succeeded in obtaining it, will be seen from his Report. I myself have had opportunity personally to witness what, even if it be not admitted to be unequivocal proof of the true position of these sandstones with reference to another well-defined formation, must certainly be taken as very strong presumptive evidence, not only in favour of the opinion that the sandstones of Lake Superior are of Lower Silurian date, but that they underlie the palæozoic base of the Mississippi Valley.

The phenomena to which I refer, came under my notice chiefly on the upper waters of the St. Croix; and are especially worthy of attention in this connexion.

It will be remembered, that in Chapter I., when speaking of the palæontology of F. 1, I noticed the occurrence, on the St. Croix, just below its Falls, of Lingula and Orbicula beds (Tab. I., B, & F. 1, *b*); and stated, that these strata, constituting the palæozoic base of the Mississippi Valley, were found in horizontal layers, in juxtaposition with the trap range. Here we have a point of departure, determined by unquestionable palæontological evidence; all admitting these beds to be of Lower Silurian date.

Now, as the general dip, throughout this entire region of country, is southeasterly, it follows that, in ascending the St. Croix, above the Falls, so long as the formation remains continuous, we gradually reach lower members of F. 1. Accordingly, we find, from the Falls up as high as the mouth of Snake, the white and buff quartzose sandstone beds of F. 1, *a*, preserving all their characteristic peculiarities, in place, at brief intervals on both sides of the river. From this point, still ascending the river, occurs a marked change, challenging the attention of the geologist. Instead of the light or yellow quartzose sandstone, which he has left behind him, he is met, commencing on the St. Croix about five miles above the mouth of Snake, by red sandstone, argillaceous, ferruginous, similar in tint and composition to the red sandstones of Lake Superior, and associated, like them, with coarse red conglomerates, and

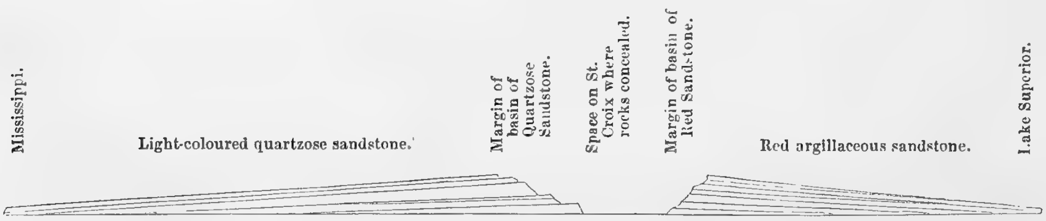
trap, in place. So, also, on Snake and Kettle Rivers, ascending to the northwest, the change is gradual, from the buff and white quartzose sandstones prevailing on the St. Croix, below the mouth of Snake, to the reddish-brown, argillaceous, ferruginous variety.

Now, it is very certain, that (if they still occupy, undisturbed, their original position) these red sandstones, so closely resembling, in aspect and connexion, the formation of Lake Superior, must rise from beneath the quartzose sandstone of F. 1, and must constitute, in fact, one of the inferior beds of that formation. And so of the red sandstones in further ascending the St. Croix. As a general rule, they retain their red tint, their argillaceous, ferruginous character, and their southeasterly dip, as far as any rocks can be traced, in place, up that stream, and until they disappear, under the drift, some ten miles below Upper St. Croix Lake, which is the source of the river.

Here, it is true, an interval of some width occurs. From the point where these rocks are lost, under drift, on the Upper St. Croix, across to where other red sandstones, similar in appearance, in their associated rocks and in their dip, are found in place on the Bois Brulé of Lake Superior, it is, in a northerly direction, about twenty-three miles; the intervening space being a region of heavy drift and erratics, in which no rocks whatever can be reached, in place.

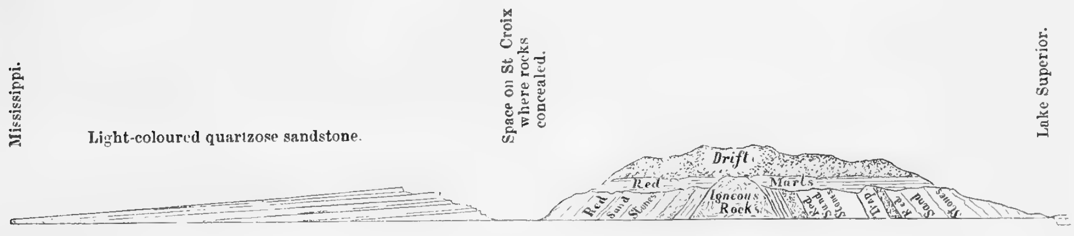
Here is a close approximation to proof, by superposition, that the red sandstones of Lake Superior underlie the Lingula and Orbicula beds of the Upper Mississippi Valley, represented on Tab. 1, B. The proof would be complete, if we could be assured, that the sandstones of the Upper St. Croix, and of Snake and Kettle Rivers, with their general southeasterly dip, have preserved the inclination of their original deposition; and, further, that in the drift-covered interval of twenty-three miles, now devoid of visible rocks, there is continuity of strata and persistence of general dip.

It is an imaginable case, however, and one which may be advanced by those who set down the sandstones of Lake Superior as of Upper Silurian or Post-Silurian date, that, at some remote distance of time, there might have existed two independent geological basins, of which the margins came together in the vicinity of the confluence of Snake River and the St. Croix; that, in the southern of these two basins, stretching down the Mississippi Valley, there might have been deposited sandstone of Lower Silurian date; while, in the northern basin, at a subsequent era, the red sandstone, with its subordinate slates and conglomerates, might have supervened, say at the Old Red or New Red Period.



THEORETICAL SECTION OF TWO ANCIENT BASINS, ONE OF QUARTZOSE SANDSTONE, THE OTHER OF RED ARGILLACEOUS SANDSTONE, IN THEIR ORIGINAL UNDISTURBED CONDITION.

It is further conceivable, that, north of the sources of the St. Croix, some subsequent upthrusting of igneous rocks, forming a main axis of dislocation, and shifting northward the original water-shed, might have raised and tilted the red sandstone strata, and thus changed their general plane of deposition from a slight northern inclination to the southeasterly dip they now present; so that the white and buff beds of F. 1, though they may seem to rest conformably on these red sandstone beds, might merely abut against them, and not, in fact, overlie them at all.



POSSIBLE PRESENT CONDITION OF THESE TWO BASINS, AFTER DISTURBANCE.

But, in the general configuration of the Lake Superior and St. Croix countries, there is nothing to verify such a supposition as this, and little to redeem it from the character of a gratuitous, unsubstantiated theory. There is nothing in the country on the St. Croix, near the mouth of Snake and Kettle Rivers, that suggests, or confirms, the idea of a former summit range, marking the barrier between two vast basins of deposit. With the exception of isolated trap upheavals, exerting on the dip a mere local and very limited influence, the country in question is as level, and apparently as free from all serious disturbances, as any other portion of the St. Croix Valley.*

Again: the general drift deposits of the interior, unfortunately, conceal from view the rocks which form the nucleus of the present water-shed between the St. Croix and the Brulé; so that we have no direct means of determining the age of its uplift. But, if we judge its interior, as we fairly may, from the character of those exposed metamorphic and Plutonic rocks, shown on the geological map crossing the head-waters of Bad River, which form the continuation of the same water-shed to the east, we are led to the conclusion, that this ridge was formed by one of the oldest disturbances that have given to this region of country its topographical features; anterior, in all probability, to the date of such an uplift as we have imagined to have removed, some thirty miles to the north, the original dividing ridge between the waters of the Lake and the Gulf.

That dividing ridge, also, is, at this point, of elevation too inconsiderable to have reversed the dip of strata over the supposed distance. The rise, on the portage

* The ridges on either side the St. Croix, in this vicinity, do not exceed from forty to fifty feet in height. Up Snake and Kettle Rivers, above the Falls, some points of cliffs reach a hundred and fifty feet. At the Dalles of the St. Croix, about thirty-five miles further south, and, of course, under any supposition, within the original Mississippi basin, the disturbances are much more considerable, the trap summits on the river extending two or three miles, and reaching the height of a hundred and seventy feet.

between the heads of the Brulé and St. Croix, is but 120 feet; and though the eastern extension of the ridge in question, between the Manidowish and head-waters of Montreal River, reaches an elevation of about 1,150 feet, its entire elevation above the Lake level, where it separates the St. Croix and the Brulé, scarcely exceeds 650 feet; and, as it extends westward, it sinks to less than 500, probably to 400 feet.

To all this is to be added the highly important fact, substantiated by Dr. Norwood's observations and my own, *of the general prevalence throughout all the sandstones* (ferruginous, as well as light-coloured, of Wisconsin and Minnesota, whether west or south of Lake Superior,*) *of a southeasterly dip*,—a phenomenon wholly at variance with the supposition that a basin once existed, stretching, with a northern dip, from its southern margin on the Upper St. Croix; a phenomenon, in fact, which can be reasonably explained only by regarding the great Plutonic chain, which lies north of the Lake, and runs nearly parallel with its north shore, from northeast to southwest, as the main axis of dislocation, whence the sandstones in question stretch, with a long, gradual, southeasterly slope, not arrested, in its general inclination, by the low water-shed between the Lake and the Mississippi, but passing on, and reaching down the valley of that river, until it disappears beneath the Lower Magnesian Limestone of Southern Wisconsin. With this view coincides the fact, that the dip in question is considerably greater north of the Lake than south of it. From its south shore, across to the Mississippi Valley, the dip of the strata, when undisturbed by subordinate igneous intrusions, does not, probably, average more than six or seven degrees; and, at many localities, it approaches a level.

I conceive, then, that the natural and reasonable inference, in ascending the St. Croix and meeting red sandstone beds, with a dip corresponding to that of the adjacent white and buff sandstone, is, that the red sandstone in question is a lower member of F. 1, and that the white and buff layers do actually rest conformably upon it.

This reasonable inference is further confirmed by the fact, that, on several localities, on various other tributaries of the Upper Mississippi, phenomena somewhat similar to those noticed on the St. Croix have been observed. On the St. Peter's, near its confluence with the Waraju; on the Wisconsin, eight miles above its Dalles; on the Barraboo, near Devil's Lake; on the Cedar Branch of the Chippewa, near its head,—the lowest beds of sandstone, found usually in proximity to the low ranges

* With the exception of the high, northern dip of the sandstone, at the mouth of Montreal River (see Colonel Whittlesey's Section, No. 4, and also the wood-cut at the close of this chapter), tilted by a trap range, which cuts across that river, only a few hundred yards above its junction with the Lake, there has not been observed, on the southern shore, from Montreal River to Fond du Lac, a single bed of sandstone or its associated rocks, of which the dip, when it could be detected, was not southeasterly; not one which dipped northerly towards the Lake; though many writers have assumed this latter to be the true state of the case, and have thence been led into sundry false conclusions, touching the formations of this region of country.

On the several forks of Bad River (see Colonel Whittlesey's Sections), on the Brulé, and other Wisconsin streams that empty into the Lake, there are, crossing them at certain points, trap intrusions, which tilt the strata, often at a high angle, to the north, for a limited distance; but as soon as their immediate influence ceases (which rarely reaches two or three miles, usually much less), the strata conform to their usual place of deposition, to the southeast.

of granite, exhibit the same deep red, ferruginous appearance, as the Lake Superior sandstones. More quartzose, indeed, these usually are, some being true ferruginous quartzites; but still, in their general character, more nearly allied to the Lake Superior rocks, than to the white and buff beds, to which, in the descending order, they succeed.

I am further of opinion, that the red sandstones of Lake Superior, in Wisconsin and Minnesota, are but a continuation of the same ferruginous, argillaceous variety, greatly expanded in thickness, which rises to view on the Upper St. Croix, and owes its peculiarity to some local, modifying cause, perhaps to the influence of ferruginous waters, brought into action in a district of country that has been evidently subjected, throughout a long period of time, to repeated volcanic eruptions, and of which the structure indicates the frequent presence of iron; and that they, with their associated slates and conglomerates, form the lowest sedimentary strata, throughout this entire region of country.

If this be the true age of these rocks, it cannot surprise us, that they should have been searched in vain for characteristic fossils. The absence of such fossils is a strong argument in favour of the opinion which places them below the palæozoic base of the Mississippi Valley. It would not be easy to find, either in the Old Red, the New Red, or the Upper Silurian Period, beds of red sandstone, attaining, as the sandstones of Lake Superior doubtless do, to a thickness of more than five thousand feet, and which have proved, throughout the whole of that thickness, so nearly azoic.

In accordance with the views herein expressed, I have, on the final Geological Chart of this District, given to these sandstones, at the various points where they are seen emerging from beneath the concealing drift, and other superficial deposits, the chrome-yellow colour employed to designate F. 1. The superficial red marls and clays, which engross so much of the surface of the southern shore, covering up alike the thick masses of sandstone, with their associated rocks, and in part the igneous protrusions also, are coloured of a pale red tint.

TILTED STRATA OF RED SANDSTONE, LAKE SUPERIOR.

CHAPTER VI.

INCIDENTAL OBSERVATIONS ON THE MISSOURI RIVER, AND ON THE MAUVAISES TERRES (BAD LANDS).

In the instructions forwarded to me in the spring of 1849, by the Commissioner of the General Land Office, for my guidance during that season, I was directed to extend the Survey into Iowa more than had hitherto been done. In fulfilling these instructions, I was desirous, if possible, to connect the geology of the Mississippi Valley, through Iowa, with the cretaceous and tertiary formations of the Upper Missouri; a matter very important to the proper understanding of the formations of the intervening country, which it had been made my particular duty to explore.

I visited St. Louis early in May of that year, for the purpose of making the necessary arrangements to ascend the Missouri, with the intention of going up the Sioux River, crossing from its head-waters by land, near the northern boundary line of Iowa, and descending the Des Moines in canoes, if it was found practicable to make a portage to the head-waters of that stream.

But, owing to the difficulty of obtaining men, in consequence of the panic caused by the prevalence of the cholera on the Missouri, I was compelled to abandon my first intention; and finally determined to commence my explorations on the Iowa and Des Moines Rivers and adjacent country; intending, towards the close of the season, to cross, by land, from the latter river to the Missouri.

Finding that it would be quite unsafe to rely on procuring supplies so high up the Missouri as, on my return route, I intended to strike, I directed Mr. J. Evans, one of my subagents, to proceed up that river, for the purpose of making the necessary deposits of provisions, at suitable points, to meet the wants of my corps. And, as it would be impossible for him to rejoin me after performing these duties, I further instructed that gentleman, while awaiting my arrival, to employ his time in examinations in the vicinity of the Upper Missouri River, as far as the means at his command would admit; and, if possible, to trace out the boundaries of the cretaceous and tertiary formations west of that river, with special reference to their connexion with the formations of Iowa.

In following up these instructions, he was enabled to extend his observations over a much larger tract than was at first anticipated, in consequence of facilities

afforded to him by the Fur Company, both in passing rapidly from point to point, on the river, and afterwards in procuring the means of land travel, which he otherwise could not have obtained, and by which he finally reached that most curious unexplored region, the country of the "Bad Lands" (Mauvaises Terres), lying high up on White River; a locality which seemed likely, above all others, to furnish satisfactory information regarding the precise character and age of the tertiary deposits of the Upper Missouri country.

The following is the substance of Mr. Evans's Report:

After having first struck, near the mouth of the Ayoway, the cretaceous formation, possessing the lithological character as described in Nicollet's Report, he traced it, with some local variations in its beds, in a northwest direction, to a point on the Missouri, three hundred miles below the Yellowstone, and one hundred and thirty miles west from Fort Pierre.

In the Fox Hills, which form the dividing ridge between the Cheyenne and Morean Rivers, as indicated on the small map, he found the upper members of this formation particularly characterized by a species of *Cucullæa,* allied to, but not identical with, *C. transversa* (see Table VII. Fig. 1); by *Ammonites Nicollettii* (Table VIII. Fig. 1); by *Ammonites Conradi* (?) (Table VIII. Figs. 2 and 3); by *Scaphites nodosus* (Table VIII. Fig. 4); by *Ammonites lenticularis* (Table VIII. Fig. 5), some specimens of which attain a diameter of thirteen inches; and by portions of other Ammonites, some, perhaps, identical with *A. placenta,* of De Kay, and which appear occasionally to have attained the size of a small carriage-wheel.

On Sage Creek, a southern branch of the Cheyenne, *Inocerami* are very abundant, some of unusual dimensions. The most remarkable are, *I. Barabini* (?), *I. mytiloides* (?) (Table VII. Fig. 3), a species occurring in the chalk formation of Westphalia; and a very large species belonging to the same genus, probably an undescribed species, measuring upwards of nine inches in length and six in breadth. Along with these are several species of *Baculites,* usually in disjointed pieces.

At the Great Bend of the Missouri, in addition to several of the same Ammonites and Baculites, occur *Inoceramus cripsii,* and *Ammonites opalus,* a new species (Table VIII. Fig. 6).

At Grand River, where there is much selenite in the rocks, a small species of *Inoceramus* prevails.

At most of these localities, and especially on Sage Creek, the Ammonites and other fossils form the nucleus of argillaceous and ferruginous septaria, which lie strewn on the surface, or scattered in the beds of the streams; the soft, argillo-calcareous matrix having been washed from around them. Some of these possess the character of ironstones; others have the property of hydraulic cement. The fossils are mostly procured by breaking up these septaria, which are of very irregular fracture; and it is therefore difficult to obtain them entire.

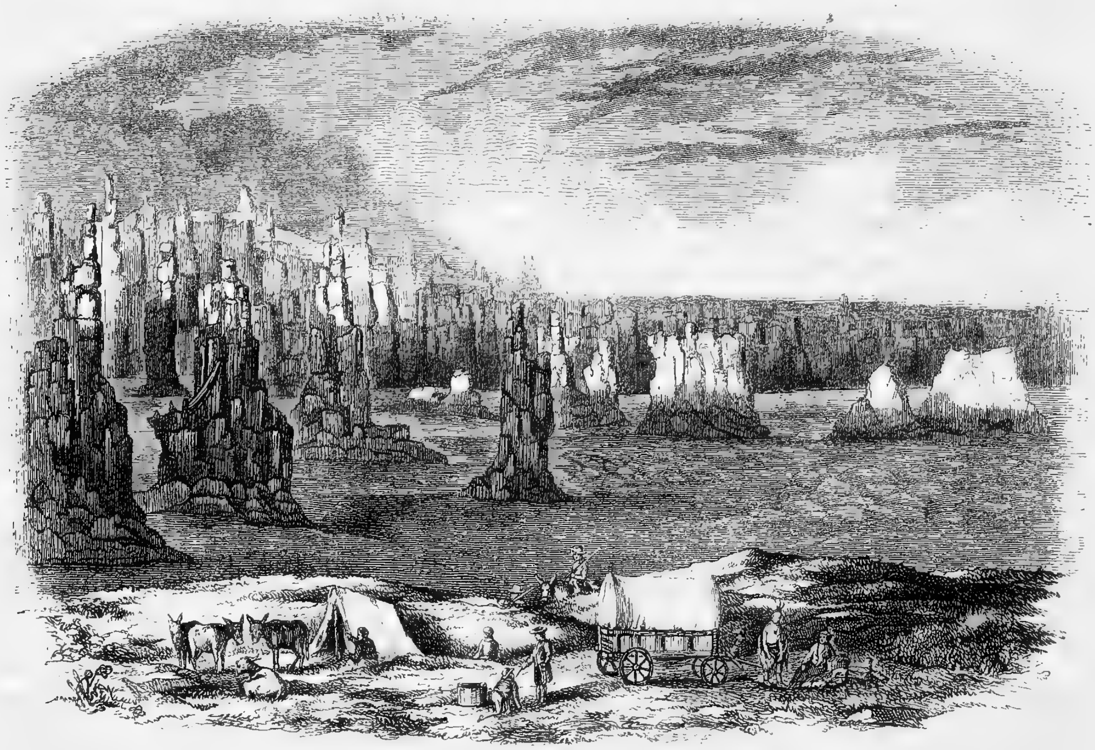
The shelly matter of the fossils usually presents all the appearance of the original nacre, often reflecting, at the same time, the most brilliant iridescent hues.

Below Fort Clark, the great lignite formation first shows itself in the banks of the Missouri. It was traced to a point twenty miles below the Yellowstone.

One of the thickest and most valuable beds of coal observed by Mr. Evans, occurs

near Fort Berthold, where it is from four to six feet thick. I had not time to submit this coal to a rigid chemical examination by combustion with copper scales. A preliminary examination showed it to be of a remarkable character. In burning, it emits a peculiar odour, and gives out but little flame. Its specific gravity is 1·33. Of volatile matter, there is 54·5, chiefly light carburetted hydrogen; of carbon or coke, 37·0; of coke itself, 45·5; of light green ashes, 8·5. A hundred grammes of nitre required 27·8 for deflagration; which, if 12 be taken as the amount necessary to deflagrate the same nitre, would give about 43 per cent. of carbon in both coke and volatile matter, and about 6 per cent. of carbon in the volatile matter alone.

This coal does not present the appearance either of true lignite, or of brown coal. It has more the aspect of ordinary bituminous coal; especially of the poorer varieties of splint or cannel coal. It is unlike them, however, in its elementary constituents; for, when exposed to heat, little or no coal-gas is given out, but only a little carbonic acid and light carburetted hydrogen. It smoulders away, more like anthracite; which, however, it does not resemble either in structure, lustre, or proportion of carbon.



MAUVAISES TERRES, NEBRASKA.

After leaving the locality on Sage Creek, affording the above-mentioned fossils, crossing that stream, and proceeding in the direction of White River, about twelve or fifteen miles, the formation of the Mauvaises Terres proper bursts into view, disclosing, as here depicted, one of the most extraordinary and picturesque sights that can be found in the whole Missouri country.

From the high prairies, that rise in the background, by a series of terraces or

benches, towards the spurs of the Rocky Mountains, the traveller looks down into an extensive valley, that may be said to constitute a world of its own, and which appears to have been formed, partly by an extensive vertical fault, partly by the long-continued influence of the scooping action of denudation.

The width of this valley may be about thirty miles, and its whole length about ninety, as it stretches away westwardly, towards the base of the gloomy and dark range of mountains known as the Black Hills.* Its most depressed portion, three hundred feet below the general level of the surrounding country, is clothed with scanty grasses, and covered by a soil similar to that of the higher ground.

To the surrounding country, however, the Mauvaises Terres present the most striking contrast. From the uniform, monotonous, open prairie, the traveller suddenly descends, one or two hundred feet, into a valley that looks as if it had sunk away from the surrounding world; leaving standing, all over it, thousands of abrupt, irregular, prismatic, and columnar masses, frequently capped with irregular pyramids, and stretching up to a height of from one to two hundred feet, or more.

So thickly are these natural towers studded over the surface of this extraordinary region, that the traveller threads his way through deep, confined, labyrinthine passages, not unlike the narrow, irregular streets and lanes of some quaint old town of the European Continent. Viewed in the distance, indeed, these rocky piles, in their endless succession, assume the appearance of massive, artificial structures, decked out with all the accessories of buttress and turret, arched doorway and clustered shaft, pinnacle, and finial, and tapering spire.

One might almost imagine oneself approaching some magnificent city of the dead, where the labour and the genius of forgotten nations had left behind them a multitude of monuments of art and skill.

On descending from the heights, however, and proceeding to thread this vast labyrinth, and inspect, in detail, its deep, intricate recesses, the realities of the scene soon dissipate the delusions of the distance. The castellated forms which fancy had conjured up have vanished; and around one, on every side, is bleak and barren desolation.

Then, too, if the exploration be made in midsummer, the scorching rays of the sun, pouring down in the hundred defiles that conduct the wayfarer through this pathless waste, are reflected back from the white or ash-coloured walls that rise around, unmitigated by a breath of air, or the shelter of a solitary shrub.

The drooping spirits of the scorched geologist are not permitted, however, to flag. The fossil treasures of the way, well repay its sultriness and fatigue. At every step, objects of the highest interest present themselves. Embedded in the debris, lie strewn, in the greatest profusion, organic relics of extinct animals. All speak of a vast fresh-water deposit of the early Tertiary Period, and disclose the former existence of most remarkable races, that roamed about in bygone ages high up in the Valley of the Missouri, towards the sources of its western tributaries; where now pastures the big-horned *Ovis montana*, the shaggy buffalo or American bison, and the elegant and slenderly-constructed antelope.

* See small map of Bad Lands.

Every specimen as yet brought from the Bad Lands, proves to be of species that became exterminated before the mammoth and mastodon lived, and differ in their specific character, not alone from all living animals, but also from all fossils obtained even from cotemporaneous geological formations elsewhere.

Along with a single existing genus, the Rhinoceros, many new genera never before known to science have been discovered, and some, to us at this day, anomalous families, which combine in their anatomy structures now found only in different orders. They form, indeed, connecting links between the pachyderms, plantigrades, and digitigrades. For example, in one of the specimens from this strange locality, described by Dr. Leidy under the name of *Archiotherium*, we find united characters belonging now to the above three orders; for the molar teeth are constructed after the model of those of the hog, peccary, and babyroussa; the canines as in the bear; while the upper part of the skull, the cheek-bones, and the temporal fossa assume the form and dimensions which belong to the cat tribe. Another, the *Oreodon* of Leidy, has grinding teeth like the elk and deer, with canines resembling the omnivorous thick-skinned animals; being, in fact, a race which lived both on flesh and vegetables, and yet chewed the cud like our cloven-footed grazers.

Associated with these extinct races, we behold also, in the Mauvaises Terres, abundant remains of fossil pachydermata, of gigantic dimensions, and allied in their anatomy to that singular family of proboscidate animals, of which the tapir may be taken as a living type. These form a connecting link between the tapir and the rhinoceros; while, in the structure of their grinders, they are intermediate between the daman and rhinoceros; by their canines and incisors, they connect the tapir with the horse, on the one hand, and with the peccary and hog on the other. They belong to the same genus of which the labours of the great Cuvier first disclosed the history, under the name of *Palæotherium*, in publishing his description of the fossil bones exhumed from the gypsum quarries of Montmartre, near Paris, but are of distinct species; and one, at least, of this genus, discovered in the Bad Lands (*Palæotherium Proutii*), must have attained a much larger size than any which the Paris basin afforded. In a green, argillo-calcareous, indurated stratum, situated within ten feet of the base of the section, a jaw of this species was found, measuring, as it lay in its matrix, five feet along the range of the teeth, but in such a friable condition, that only a portion of it could be dislodged; and this, notwithstanding all the precautions used in packing and transportation, fell to pieces before reaching Indiana.

A nearly entire skeleton of the same animal was discovered, in a similar position, which measured, as it lay embedded, *eighteen feet* in length, and *nine* feet in height. But here, as in the former case, the crumbling condition of the bones rendered it impossible to disinter them whole; and the means of transportation to the Missouri were insufficient, even if these interesting remains could have been extracted in good condition.

Some teeth and imperfect jaws, from the same bed, appear to belong to a genus established, in 1847, by Dr. Leidy, under the name of *Poëbrotherium*, an animal which he considers intermediate between the *Dorcatherium* and the *Anoplotherium*.

Many bones, skulls, and teeth were collected from a flesh-coloured, indurated,

calcareo-siliceous marl, that occupies a higher level, forming part of No. 8, as exhibited in the Section showing the different beds which compose this eocene tertiary formation. These belong chiefly to those lost races of ruminating pachyderms, some of which are remarkable for the continuity of the whole range of grinders, canine, and incisor teeth; having a scarcely greater interval between the different sets than man himself.

Some of the specimens obtained in this bed are in a good state of preservation, and exhibit the whole range of molars, both in the upper and lower jaws, as well as the upper and lower canine teeth.

The structure of the grinders of some species indicates that they may probably be referred to that species of ruminating pachyderms established, by Dr. Leidy, under the name of *Oreodon Culbertsonii.* Others appear to belong to genera and species not heretofore described, but belonging to the same family of ungulate ruminants.

One of the most perfectly preserved skulls in the collection, and the one next in size to the *Palæotherium Proutii,* is a new species of *Rhinoceros,* belonging to Kaup's subgenus of hornless rhinoceros, *Acerotherium* (Table IX., Fig. 1); the cranium of which measured over sixteen inches in length, without the terminating portions of the nasal bones, which were deficient. The structure of the molar teeth of the upper jaw of another specimen, belonging to the same subgenus, approaches somewhat to *Rhinoceros liptorhinus,* though sufficiently distinct in the disposition of the cusps and lobes, so that Dr. Leidy has described it, in his accompanying memoir, under the name of *R. Nebrascensis.* A view of the whole range of molars and premolars of this fossil is seen in Fig. 6, on Table XII., A., engraved from a daguerreotype, reduced nearly to one-fifth the size of the original. Two other skulls, deficient only in the anterior part of muzzle, display the molars and premolars in an excellent state of preservation (Table X., Figs. 1, 2, and 3; and Table XI., Fig. 2). They belong to a new genus, heretofore alluded to, partaking of the characters found in the *Hyracotherium* and *Cheropotamus;* animals, which, though they were much larger, bore considerable resemblance to the living babyroussa and peccary.

Amongst the unique assemblage of extinct pachyderms, this Survey has furnished but one specimen of a truly carnivorous type of animal, with prehensile claws; and, I believe, the collections subsequently made by Mr. Culbertson, in the same field, furnishes no further example. It is a portion of a fossil skull, referable to that remarkable genus of fossil Felidæ, the *Machairodus* or *Felis Smilodus,* from Brazil; unfortunately, it is in a worse state of preservation than most of the other specimens of the collection. Its profile is engraved on Table XII., A, Fig. 5, from a daguerreotype, reduced nearly one-half from the original.

Besides these various remains of singular forms of mammiferæ, there were also discovered many turtles, reduced figures of which are given on Table XII., and Table XII., A, Figs. 1, 2, 3, 4, and Table XII., B, Figs. 1 and 2; some of huge dimensions. The largest which we were able to transport, and which is represented (Table XII., Figs. 1 and 2) two-fifths the natural size, measured sixteen inches by thirteen and a quarter, and weighed upwards of fifty-eight pounds. But others were seen, which, with the means at command, it was impossible to remove, estimated to weigh a ton.

Naturalists who have inspected the fossil turtles from the Mauvaises Terres, have found great difficulty in deciding whether they should be referred to the genus *Emys* or to *Testudo*.

It is, I believe, agreed that, in their general aspect and contour, they resemble more the usual form of aquatic turtles than the terrestrial tortoise; but Dr. Leidy has shown, from the details of their comparative anatomy, that in certain structures of the intercostal portion of their shelly covering, and in the intervention of a peculiar and somewhat rhomboidal-shaped plate, in the posterior part of the carapace, they approximate more closely to the *Testudo*, and differ, in this respect, from all living *Emys*, he has had an opportunity of examining; and, for this reason, he has referred these fossil turtles, brought from the Mauvaises Terres, to the former genus. Nevertheless, it is highly probable, from the great number of their remains discovered in a limited space, that they were aquatic in their habits, and, if so, may form an intermediate genus or subgenus—a lost link—between the existing aquatic turtles and terrestrial tortoises. For further particulars on this head, I must refer the reader to Dr. Leidy's interesting memoir.

These turtles were chiefly observed in a portion of the " Bad Lands," some five or six miles in extent, which has much the appearance of an ancient lake, where it is entered from Bear Creek, a tributary of the Cheyenne.* At one of these lake-like expansions, hundreds of fossil turtles were discovered. They do not rest immediately on the grassy plain that forms the present floor or bottom, but on the talus and debris, collected into mounds, which have been derived from the disintegration of the marly earths that have slid from above. The particular stratum in which they seem to have been originally embedded, is a pale flesh-coloured, indurated, siliceous, marly limestone, situated from thirty to fifty feet above, as shown in No. 7, of the following section.

SECTION OF BEDS CONSTITUTING THE EARLY TERTIARY (EOCENE) OF THE BAD LANDS (MAUVAISES TERRES).

(Numbered in the descending order.)

		Feet.	Inches.
1.	Ash-coloured clay, cracking in the sun, containing siliceous concretions,	30	
2.	Compact white limestone, ...	3	
3.	Light-gray marly limestone, ...	8	
4.	Light-gray indurated siliceous clay (not effervescent), . . .	30	
5.	Aggregate of small angular grains of quartz, or conglomerate, cemented by calcareous earth, slightly effervescent, ...	8	
6.	Layer of quartz and chalcedony (probably only partial), . .		1
7.	Light-gray indurated siliceous clay, similar to No. 4, but more calcareous, passing downwards into pale flesh-coloured, indurated, siliceous, marly, limestone (effervescent), turtle and bone bed, . .	25	
8.	White and light-gray calcareous grit, slightly effervescent, . .	15	
9.	Similar aggregate to No. 5, but coarser, ...	8	
10.	Light-green, indurated, argillaceous stratum; (slightly effervescent); Palæotherian bed, ...	20	

* See small map.

For a further and more detailed account of the comparative anatomy of the fossil mammalia collected on this Survey, the reader is referred to Dr. Leidy's accompanying Memoir.

The investigations connected with the geology of this curious country, and the natural history of its ancient Fauna, are invested with no small degree of interest, when we consider that, at the time these singular animals roamed over the Mauvaises Terres of the Upper Missouri, the configuration of our present continents was very different from what it now is. Europe and Asia were then, in fact, no continents at all, being represented only by a few islands, scattered over a wide expanse of ocean. The Atlantic seaboard of the United States, back to the mountain ranges, and up the Valley of the Mississippi as high as Vicksburg, was yet under water. Mount Etna, that remarkable volcanic cone of Sicily, nearly 11,000 feet in height, was yet unformed, and the fertile plateau of that island, more than 100 miles in circumference, was still deep under the Tertiary Mediterranean Sea. In Europe, during the period following the extermination of the eocene Fauna of Nebraska, the Alps have been heaved up nearly their whole height; and in Northern India, the whole Subhimalayan Range has been elevated. In South America, 9,000 feet have been added to the height of the Cordilleras, and the South Atlantic has been driven back 700 miles, while a district of country 2,500 miles in length, from the Great Plain of the Amazons to the Straits of Magellan, has emerged from the ocean.

Some of my readers, who have not made Geology a particular study, may be curious to follow the course of reasoning by which geologists have arrived at such startling results—results which must, no doubt, appear to them incredible.

In Europe, in Asia, and both North and South America, science has long observed and studied particular geological formations, which, in all these countries, have a certain degree of uniformity of organic remains therein embedded. These are, chiefly, an assemblage of marine shells and corals, which, though they differ, in most instances, in trivial minutiæ of form, yet bear a close resemblance to the very shells and corals now inhabiting our seas, and which are cast by thousands on our shores.

It is not in a few rare instances alone, that these fossil shells are detected embedded in the substance of the rocks in question; many of the strata, and especially those that contain much lime, actually teem with these exuviæ; and, not unfrequently, as in Florida and Mississippi, they are but an agglutinated aggregate of marine productions. We have, indeed, the most unequivocal proof, that all the strata composing this formation have been a succession of sediments or precipitates consolidated at the *bottom of the ocean*. Alternating with these beds there are also others interstratified, filled with the bones of quadrupeds which have perished on the banks and near the mouths of rivers, whence they have been swept into estuaries and bays, and entombed in the sediments there accumulating. In the occurrence of such mammalian remains, the geological formations to which the attention of the reader is now called, differ essentially from every other which underlies them, and which, therefore, are of more ancient date; since it is a self-evident fact, that

the upper layers of sedimentary deposits must always be the newest and last to have settled down.

These bone and shell beds constitute what is now known as the Tertiary or Cainozoic grand division of the fossiliferous rocks, and overlies the chalk of England and the cotemporaneous marly limestones and argillaceous beds of this country; and, with the exception of transported, superficial sands, gravel, erratics, marls, and alluvial earths, are, unquestionably, the most recent of the sedimentary strata. These tertiary rocks are of great thickness, and admit of being subdivided into subordinate groups and members, of older and newer dates—chronologically, as well as palæontologically, distinctly separable from each other: thus we have become acquainted with a lower, a middle, and an upper group, and even subdivisions of these groups, in each of which peculiar and distinct races of animals are found. By these, any given member can at once be identified, even on remote continents. For instance, the gigantic animal, the skeleton of which was discovered in the Bad Lands, called the *Palæotherium,* characterizes the lowest group of the formation: its remains are confined exclusively to these eocene beds, both in Europe and this country; whereby we learn that this animal lived during the dawn of that geological epoch, and became entirely extinct before the middle group began to accumulate, which latter does not contain a vestige of their bones, though rich in the remains of an entirely different set of extinct animals. The same is true of the uppermost and most modern beds of the formation, as compared with the middle and lowest divisions.

Now it is an axiom in Geology, which all experience fully confirms, that there never is any reversal of superposition,—these tertiary beds invariably occupying the same relative position with respect to the chalk formation; being always above it—never below it, so long as they remain in their original undisturbed condition. They may be twisted, contorted, and sometimes even turned and folded under the upper, over limited spaces; but these are local inversions of the order of arrangement by subsequent disturbance, and occur only in mountain chains, in which powerful subterranean forces have been at work; and close observation can even there, in many instances, trace the continuity of strata around the axis of the plicated, subverted beds.

In such situations, the strata may be baked, indurated, and greatly altered from their original appearance, but all this does not, by any means, militate against the general proposition. Wherever organic remains can in such cases be detected, they always prove to be infallible guides to unravel the complicated structure, and solve the difficult geological problems which such regions frequently present.

Another self-evident fact of this science regards all strata which have been rent asunder, broken, tilted, or otherwise disturbed, as, in every case, more ancient than the dislocating forces and eruptions producing such derangement of the bed; and older, also, than the rocks which, in a nascent state, may be thrust up through the fissures and parted walls of the superincumbent layers.

Admitting these facts, the corollary follows, which determines the age of mountain chains; and which may now be illustrated by demonstrating the period of the

principal uplift, which gave origin to the highest and most extensive range of mountains in all Europe.

Amongst the sedimentary strata forming part of the flanks of the Alps, there are certain dark-coloured slates, marls, and sandstones, known in Switzerland by the name of Flysch. These beds are implicated in the gigantic movements which have convulsed the whole of Switzerland, and they have been carried on the crests of the intruding masses, in their upward course, until they have actually been raised more than ten thousand feet—nearly to the highest summits of the chain. This effect was produced, not by one violent, tremendous eruption, but rather by a long succession of oscillatory movements—by contractions and subsidence of the rocks during periods of repose, and the extinguishment of volcanic fires; and by the expansion of the wedge-shaped nucleus, as well as by the ejection of incandescent materials, during the rekindling of the irresistible chemical reactions called into activity by interchanges of elective affinities going forward in the great laboratory of nature—the bowels of the earth.

The question now arises: Can we determine the age of these disturbed Flysch beds? Can we refer them to any known group of sedimentary strata, the age of which is well established? If so, we have the clue—we have the data, the proof—the *quid erat demonstrari*, by which the period of formation of the Alps is mathematically demonstrated. The Flysch beds were long regarded as of great geological antiquity, anterior even to the great coal formation; but, in the language of a French geologist, "the longer they were studied, the younger they grew;" and this, notwithstanding their great hardness, solidity, or even local crystalline structure. Now, all the most experienced geologists of Europe admit that, so far from being classed with the Palæozoic Rocks, their position *above the nummulite limestone* has latterly proved that they really belong to the eocene or early tertiary, which subdivision contains, in France, the celebrated gypsum quarries of Montmartre, heretofore alluded to as containing the remains of *Palæotherium*, and other remarkable extinct quadrupeds, and which are cotemporaneous with the Nebraska beds affording a gigantic variety of the same genus, and the other coeval extinct races which form so interesting a feature in the palæontology of the Mauvaises Terres.

Thus it is that the geologist is able to prove, as satisfactorily as can be demonstrated a mathematical problem, that, at the time these fossil mammalia of Nebraska lived, the ocean still ebbed and flowed over Switzerland, including the present site of the Alps, whose highest summits then only reached above its surface, constituting a small archipelago of a few distant islands in the great expanse of the tertiary sea.

In corroboration of this opinion, I subjoin, in this connexion, a few extracts from the able address of Sir Charles Lyell to the Geological Society of London, in 1850, proving that these views are based on palæontological evidence, which has been thoroughly scrutinized by the most proficient naturalists of the age:—

"The researches of Sir Roderick Murchison in the Alps, in 1847, and the palæontological evidence of various eminent writers, brought together by him in illustration of his views, have, I think, shown unequivocally, that, together with the

nummulitic limestone, an enormous thickness of overlying strata of dark-coloured slates, marlites, and fucoidal sandstones, provincially called Flysch, must be regarded as lower eocene."

And in another place, speaking of the epoch of the underlying nummulitic limestone, whether it should be referred to the cretaceous (chalk formation) or tertiary, we find the following:—

"M. Boué indeed announced, in 1847, his own conviction, that the nummulitic rocks belonged to the eocene or lower tertiary period, and remarked, in a paper read to the French Geological Society in that year, how much delight Alexander Brongniart would have experienced, had he lived to see one of his boldest and most startling generalizations thus crowned with success. Alexander Brongniart had in fact declared, many years before, that the shells of the summit of the Diablerets, one of the loftiest of the Swiss Alps, which rises more than 10,000 feet above the sea, were referable to species characteristic of the eocene tertiary of the neighbourhood of Paris."

* * * * * *

"Were we to endeavour to estimate the changes in physical geography which can be proved by the position of these marine eocene strata to have occurred since the commencement of the tertiary period, we should find them to be very inadequately expressed by stating, that they equal in amount the conversion of sea into land of a continent as large and lofty as that of Europe, Asia, and the north of Africa. I endeavoured, in 1834, in a map constructed for the 3d edition of my 'Principles of Geology,' to show the extent of surface in Europe, and part of Asia, which had been covered by water, at some time or other, since the beginning of the eocene period. But, had I been then aware, that a true pictorial representation of such modern revolutions in physical geography would have required the submergence of the Alps, Pyrenees, Apennines, and Carpathians, and the insertion of a few insignificant islands only in their place, I might have thought such an illustration superfluous or without meaning, and been satisfied by simply insisting on the post-eocene ubiquity of the ocean—not, indeed, by a simultaneous, but by a successive occupancy of the whole ground. But how small a portion even of the superficial remodeling of the earth's crust in recent times is expressed, by declaring that we can establish, by direct proof, or legitimate inference, the upheaval out of the sea of all the land in Europe, Asia, and part of Africa! During the same tertiary periods, there have been vertical subsidences as well as elevations; and we have every reason to believe, that the larger part of the globe (comprising nearly three-fourths of its superficies) which is covered with water, has undergone, in equal periods of time, oscillations of level not inferior in degree to those to which the continental spaces have been subjected. If, therefore, we were to confine our thoughts to the mere outward modifications, in the shape of the land or bed of the sea, and all the changes of climate and fluctuations in organic life inseparably connected with movements which have amounted, in some cases, to more than two miles vertically in one direction, besides the lateral displacement of rocks and their denuda-

tion by water, the series of events would seem endless, and their magnitude not easily to be exaggerated. But it is evident that these superficial mutations are trifling in amount, in comparison with revolutions which must have been going on simultaneously in the inferior parts of the earth's crust. The reality of these changes is certain, although their nature may be obscure; for we can rarely catch a glimpse of the subterranean products of the eocene, miocene, and pliocene epochs, because it requires far more time than the tertiary periods have as yet furnished, to allow the disturbing causes to uplift, depress, and render open, or for the ocean to denude the incumbent rocks, so as to make it possible for an inhabitant of the surface to behold them and appreciate their magnitude.

"The Alps indeed, where the convulsions have been greatest, reveal to us some movements of the vast chemical changes and re-arrangement of the component elements of rocks which have taken place since the deposition of the eocene tertiary strata, and we thus gain some insight into the nature of the transformation of mineral masses, which must have been going on cotemporaneously at greater depths.

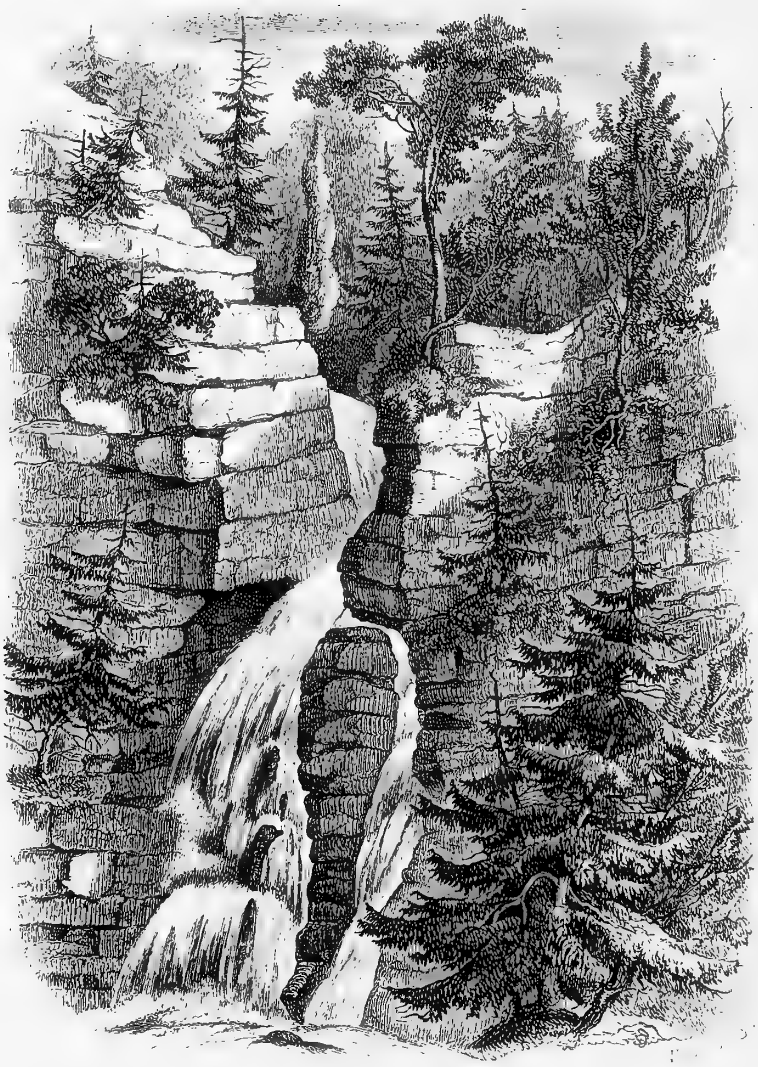
"But although it is only in a few narrow strips of country, like the Central Alps, that nature discloses to us some of the nether-formed rocks of such modern geological eras, we cannot doubt that still greater modifications of the interior have extended down for many miles or leagues in depth beneath the Alps, and beneath every region, whether of land or sea, which has risen, sunk, or oscillated in level, since the fossil shells and zoophytes of the lower eocene period were living in the sea. How much fracture and dislocation of solid rock must have taken place! How much heating and cooling, expansion and contraction, drying and baking, softening and resolidifying of sedimentary strata! Over how vast an area, and to how great a depth, often hundreds of yards or several miles beneath the surface, have mineral masses been injected by lava, or dissolved by thermal waters, or corroded by acids, or permeated by steam, or impregnated with magnesia, sulphuric acid, or other substances introduced in a gaseous form! What obliteration has there not been of organic remains, and of the signs of stratification, in the course of the tertiary ages which have elapsed since the nummulitic strata and incumbent fucoid grits lay submerged beneath the ocean!"

I have spoken of the eocene tertiary as modern compared with the palæozoic division below the coal-measures; this is only *geologically* and *comparatively* speaking; estimated in time—by a human epoch—the date of the eocene tertiary is immeasurably great—utterly beyond the grasp of our conceptions to appreciate, counted by single years, comprising, as it does, a cycle of geological events that has completely changed the whole physical geography of the world—turned continents into oceans, and oceans into dry land; and this, not by one grand *bouleversement* of the earth's crust, but by a long series of gradual changes, which, except at certain periods, of paroxysmal throes, occasionally occurring at long and distant intervals, was probably as slow and gradual as the present rising of the coast of Sweden out of the ocean, and the simultaneous subsidence of land over the bottom of the Polynesian Archipelago.

Turning to the figures engraved from daguerreotypes representing the anatomical

forms of the extinct animals of the Mauvaises Terres, which lived, as we have seen, during the dawn of the tertiary period; bearing in mind the fact that at the time they flourished in Nebraska, the Alps were just lifting their heads out of the ocean, how strange must it appear to the reflective mind, that the comparative anatomist, at this day, should be able to read their history—to restore them by minute descriptions, and thus embody them to the imagination as in their pristine and animated condition. Yet far more vividly do these facts come home to the individual who beholds and handles the specimens themselves. Some of them, disencumbered of the enclosing matrix, are still in such a perfect condition, and present so fresh an appearance, that the light is reflected back from the enamelled surface of the teeth with as much brilliancy as from highly polished steel. Were it not for their ponderous character, and their strange physiognomy, one might well suppose them to be the bones of recent animals, which had been bleached but for a season.

D. D. Owen.



GEOLOGICAL REPORT

OF A SURVEY OF PORTIONS OF

WISCONSIN AND MINNESOTA,

MADE

DURING THE YEARS 1847, '48, '49, AND '50,

UNDER THE DIRECTION OF

DAVID DALE OWEN, M.D.,

UNITED STATES GEOLOGIST.

BY JOSEPH G. NORWOOD, M.D.,

ASSISTANT GEOLOGIST.

TO DAVID DALE OWEN, M.D.,

PRINCIPAL GEOLOGIST FOR THE EXPLORATION

OF IOWA, WISCONSIN, AND MINNESOTA.

SIR: I send you, herewith, a Report of the observations made by me, in accordance with instructions received from you, at different times, during the progress of the Geological Survey, under your direction, in the years 1847, '48, '49, and '50.

Allow me, at the same time, to bear testimony to the ability and energy with which you conducted the work, and to express my acknowledgments for the many kindnesses received at your hands during my connexion with the Survey.

Yours, truly,

J. G. NORWOOD.

DR. J. G. NORWOOD'S REPORT.

CHAPTER I.

BOUNDARIES, AND TOPOGRAPHICAL NOTICES.

THAT portion of the territory in which observations were made during the year 1847, extends from latitude 43° to 46° 47′ 10″, and from longitude 89° 30′, to 93° 10′ 30″. It is very irregular in its general outline, and is bounded by a line commencing at the mouth of Wisconsin River, and following thence the Mississippi to the Falls of St. Anthony; from that point to the Falls of St. Louis River; crossing in its course the head-waters of Snake and Kettle Rivers; thence following the coast of Lake Superior to the mouth of Montreal River; from that place to Lac du Flambeau; thence, in a northeast direction, to a point on Wisconsin River, about ten miles, in a direct line, south of Vieux Desert Lake; and from that point along Wisconsin River to its mouth. These boundaries include an area of about 33,000 square miles, and are now mostly embraced within the limits of the State of Wisconsin, the remainder lying along the eastern and southeastern boundaries of the Territory of Minnesota.

The district of country explored in the years 1848, '49, and '50, embraces all that part of the Territory of Minnesota lying west of the St. Croix and Bois Brulé Rivers, and east of the Mississippi, and stretching northerly to the boundary line of the United States; and is included within a line extending along the Mississippi River as far as Red Cedar or Cass Lake, and thence to Red Lake; from the sources of Big Fork River, along that stream, to Rainy Lake River, and thence along the boundary line between the United States and British Territories to Lake Superior, at the mouth of Pigeon River; and from that point, along the shores of Lake Superior to the mouth of the Bois Brulé River, and up that stream to its source, and down the St. Croix to its junction with the Mississippi. These boundaries include an area of about 40,000 square miles.

In a large portion of this district, south of latitude 46° 47′ 10″, and east of longitude 92° 40′, more detailed examinations have either been made by yourself, or reported to you by other members of the corps, since my reconnoissance in 1847. I shall, therefore, devote most of this Report to that part of the Chippewa Land District, which is bounded on the south by a line drawn easterly from the mouth of Rum River to St. Croix River, in latitude 45° 15′, and including all the country north of it within the boundaries before mentioned. At the same time, I shall incorporate as much of the Report of 1847 into this, as may be necessary to illustrate the geology of such portions of the country examined that year, as have not been since more fully explored.

As might be expected of such an extent of territory, there is very great diversity in its physical features, so great, indeed, as to produce a variety in productions and climate seldom found in countries destitute of high mountain ranges, or, at least, of plateaus greatly elevated above the level of the sea. It is divided by nature into five well-defined districts, which, while they differ materially in their geology, present also considerable modifications of climate, the result of local influences peculiar to each division.

The first division, or that bordering on the Mississippi, extends through two degrees of latitude, in a direction nearly northwest from the mouth of the Wisconsin River. It is narrow, having an average breadth of only fifteen to twenty miles, except near its northern and southern terminations, where it is deflected east between Prairie du Chien and the mouth of Bad Axe River, and north between the middle of Lake Pepin and the Falls of St. Anthony.

The second division, which has an average breadth of thirty to forty miles, crosses Wisconsin River between Whitney's Rapids and Winnebago Portage, and extends in a northwesterly direction along the line of the first division. Its northeastern boundary crosses the large tributaries of the Mississippi a short distance below the falls of those rivers, and is continued until it reaches the head-waters of Rush River, when it turns directly north, and terminates somewhere between the sources of Red Cedar and Shell Rivers, and the dividing ridge, on the east side of the St. Croix, and crossing to the west side of that stream, between the mouths of Wolf Creek and Shell River, extends up the valleys of Snake and Kettle Rivers.

The third division includes all the country between the northeastern boundary line of the second division and the shores of Lake Superior, embracing all the northern chain of highlands and the sources of all the great streams east of the St. Croix and Bois Brulé Rivers; and also a broad strip of country stretching in a southwesterly direction from the southwestern bend of St. Louis River, through the Mille Lacs region, to the Mississippi, and crossing that stream between the mouths of Clear-water and Omoshkos Rivers.

The fourth division embraces all the country lying northwest of a line drawn from the mouth of Crow Wing River, through the Sandy Lake country to Savanna Portage, and extends to Red Lake, and the sources of some of the tributaries of Rainy Lake River. This district includes, also, the lake region about the sources of the Mississippi.

The fifth division comprehends all the country bounded by St. Louis and Ver-

milion Rivers on the west, the United States boundary line on the east and northeast, and Lake Superior—from the mouth of Pigeon River to Fond du Lac—on the south and southeast.

The first division is based on magnesian limestone, has a good soil, and is covered with vegetation. Throughout its whole extent the surface is undulating, with few high hills or deep valleys, and is about three-fourths prairie land. Within its limits are included the mouths of the Wisconsin, Bad Axe, Prairie à la Crosse, Black, Mountain Island, Chippewa, Rush, Buffalo, and St. Croix Rivers. It is well watered by branches of those streams, and many smaller tributaries of the Mississippi. It contains few lakes, or large ponds, until it crosses St. Croix River, when they rapidly increase in number, and marshes and wet meadows are frequently met with. In this section, also, springs occur. Some of them are, no doubt, the outlets of lakes on the neighbouring highlands, and afford a large and constant supply of water. At several points advantage has been taken of the elevation of their source above the river-level, and the streams flowing from them have been applied to manufacturing purposes.

The second division embraces a section of country made up almost entirely of barren sands, the debris of the lower sandstone of Wisconsin, with occasional patches of drift from more northern regions. It is generally "rolling," or rises in steppes from the margins of the rivers which pass through it, to the height of forty and one hundred and fifty feet above the water-level. It supports, at intervals, thin clumps of stunted trees, and a few short coarse grasses. Along the borders of some of the streams, however, occasional patches of a better sort of vegetation occur. While this division affords a passage for the rivers which rise in the highlands of the third division, few or no streams have their origin in it, the sands absorbing the rains as they fall, and thus preventing their accumulation into streams.

The loose sands, which are of great depth in many sections, are easily acted upon by prevailing winds, and give rise, by their shifting, to constant local changes of level. Along the banks of the rivers a great number of sections were observed, showing a line of former vegetation, now covered by from ten to twenty-five feet of sand. These circumstances must always render the sandy district barren. Whether the sands are likely to encroach upon the present arable lands, to any serious extent, is a question of great moment, and one which will require a long series of observations for its solution.

The third division differs widely, in many respects, from the preceding ones. Throughout a great portion of it, south of the water-shed, crystalline and metamorphic rocks either show themselves in the slopes of the hills or form the beds of the streams, underlying the soil and drift; while north of the ridge which divides the waters of Lake Superior from those of the Mississippi, they either come to the surface, or are met with under the marls and sandstones of that region.

The water-shed is formed by a series of hilly ranges, which, on the south side, commence at an average distance of forty to sixty miles from the Mississippi, and form successively the falls and rapids of all the rivers above the northeast boundary of the first division, as well as of the small streams tributary to them. The ascent is, at every point where observations were made, very gradual, and, occasionally,

for long distances, scarcely noticeable except by actual measurement. On the north side, the descent is much more rapid, the middle of the highlands approaching, generally, within twenty-five or thirty miles of Lake Superior, and in some places much nearer.

These ranges are made up of successive chains of rounded hills or knobs, with an elevation of from thirty to two hundred feet above the intervening valleys. Many of the hills are dome-shaped, and possess great regularity of outline. Most of them, however, are either oblong or irregular and ridge-like, and have an almost constant strike northeast and southwest, though many spurs are given off having various other bearings. Their summits present, almost uniformly, an assemblage of low, dome-shaped elevations, with occasional exposures of trappean and granitic rocks; the trap ridges presenting, generally, a more rugged and broken outline than the others.

This description applies to the northern ranges between the waters of Montreal River and those of the Bois Brulé. The highlands south of Fond du Lac, in the direction of Lake Pokegoma, differ from those just described, in the almost total absence of any distinctly marked ridges or chains of hills, after leaving the immediate vicinity of Lake Superior. After passing the high hills south of the Great Bend of St. Louis River, and which approach it very nearly opposite the Trading-House, eighteen miles above its mouth, the country is undulating but not knobby; and occasional small prairies, with numerous wet meadows, and tamerack, spruce, and cedar swamps, present themselves in every direction, until the head-waters of Kettle River are reached. This portion of the country resembles, in many respects, that lying along the line separating the first and second divisions, in the neighbourhood of St. Croix River. It is covered with a great depth of red marl, clays, and drift, based upon red sandstone, which is the only rock to be seen in place between St. Louis River and the head-waters of Kettle River, and that rock is only visible at a few points. In some of the valleys, crystalline boulders are so numerous, that, with little trouble, a person could step from one to another for the distance of half a mile or more. The general elevation along this line is also much less than along any other line of country traversed between the Mississippi and Lake Superior.

On no other line than the one just mentioned, are the higher lands destitute of a good growth of timber. Between the Bois Brulé and Montreal Rivers the ridges support a dense growth of both hard and soft woods, while the marshy valleys and low grounds are covered with tamerack, spruce, and hemlock. So dense is the forest over most of this region, that it is difficult to see from the top of one range to that of another, except where the summits happen to be formed by the protrusion of trappean or granitic rocks. Such points occur sufficiently often, however, to give the observer a knowledge of the general outline of the intervening country.

Although this section is, as just stated, covered with vegetation, yet there is much inequality in the soil of the hills, owing to the diversity of rocks from which it has been derived; and this gives rise to considerable inequality of vegetation, some of the ranges being covered with a much heavier and finer growth of timber

than others. Still, this inequality is much less than in other sections of country of the same extent, and less than it otherwise would be here, in consequence of the liberal dissemination of the red marls, which are distributed not only in the valleys, but up to the very summits of most of the ranges south of Lake Superior. Excepting the sections cut down by water-courses, few precipices occur throughout this whole region, and these only among the granitic and trap rocks.

The valleys between the ridges are mostly narrow, possessing often only sufficient width to carry off the drainage of the neighbouring high grounds. Where they are wider, the central part is generally occupied by tamerack swamps, and by drift, and fragments of rock derived from the neighbouring ranges. The smaller valleys, which wind among the chains of low hills which make up the main ranges, are dry, and like the hills are well wooded, have a good soil, and are sufficiently free from boulders to allow of cultivation.

West of the Bois Brulé, and south of the Great Bend of St. Louis River, the valleys, which are depressed but little below the general level of the country, are occupied, in most localities, by either swamps or natural meadows. Some of these meadows are very extensive, and bear a luxuriant growth of grass, often five or six feet in height. It is coarse, but sweet, and is said to make an excellent hay, being much used as provender for cattle in all the pineries, and in the settled parts of the territory where it grows. The soil of these valleys is generally lacustrine. Many of them present every indication of having been uncovered or drained at a comparatively recent period; while some of them are evidently in process of drainage at the present time, and so rapidly, that a large addition to the tillable land of the territory may be safely calculated upon at no very distant date. Should it become desirable to do so, the process of drainage might be easily accelerated by art, and at inconsiderable expense.

A very interesting and important characteristic of the third division, and which it possesses in common with the fourth, is the number of small lakes which abound throughout almost its whole area. The surface of the country is literally studded with them. In some sections it would be impossible to travel five miles, in any direction, without striking a lake. Although, on the eastern and western boundaries of the District, they extend farther south than the forty-fifth degree of latitude, the great body of them is situated north of a line drawn from the mouth of Little Wisconsin River to the Falls of St. Croix River. West of the Bois Brulé, they extend from the highlands south of Lake Superior, south and west, to the Mississippi; and, crossing that river, from near the Falls of St. Anthony to Lake Winibigoshish, form, about the head-waters of the Des Moines, and of the Mankato, Waraju, and Le Sueur, branches of St. Peter's River, the "Undine Region" of Nicollet; and, further north, the still greater assemblage of lakes which include the sources of the Mississippi and of Red River of the North; and beyond the northern water-shed, in the fourth district, the sources of Big Fork and Little Fork Rivers; and south of it, those of the western tributaries of the St. Louis River.

For description, the lakes of the second, third, and fourth districts, may be divided into two classes, or, rather, varieties, and the descriptions will, at the same time, apply to those of the first, and many of those of the fifth district.

The first variety includes those which belong to chains, and are the sources of all, or nearly all, the rivers of the territory. They are generally connected by small streams, often mere rivulets, possessing scarcely sufficient depth and breadth to permit the passage of light bark canoes; while, in other instances, they are formed by the expansion of the waters of larger streams, in basins, from one to two miles in diameter. Examples of this variety may be seen by referring to the head-waters of the Nemakagon, Red Cedar, Chippewa, Manidowish, Labiche, and Little Wisconsin, and various tributaries of the St. Croix, in Wisconsin; and to the sources of the Mississippi, Red River of the North, Crow Wing, Rum, Big Fork, and Mud Rivers, in Minnesota.

Among these lakes may also be mentioned those which have no connexion, except in long rainy seasons, or in the spring of the year, during the melting of the snows, when they are connected by streams which flow along valleys, once, evidently, the beds of large water-courses, but now elevated above the general level of the lakes, and converted into meadows, cranberry marshes, or swamps. Between a great proportion of the now isolated lakes west of the Bois Brulé and St. Croix Rivers, from St. Louis River to the Falls of St. Anthony, old connexions of this kind may be traced; and most of the rich valleys of that portion of the District owe their soils to lacustrine deposits, made during the long period of elevation, during and while the beds of large rivers were first converted into chains of lakes, and subsequently drained, as the process of elevation continued.

Many of the largest lakes are situated on the broad summit-level of the great water-shed, and in many cases where examinations have been made, or reliable information obtained, these lakes have been found tributary both to Lake Superior and the Mississippi. Connexions of this kind exist between the St. Croix and the Bois Brulé, at Upper St. Croix Lake, the west fork of Bad River and the Nemakagon, at Long Lake; and, as I was assured by the Indians residing in the vicinity, such an interlockage occurs between a branch of Kettle River, and one of Lefthand River, somewhere in the neighbourhood of Hornhanging Lake. I have also reason to believe, that such a connexion exists between the sources of Big Fork River, which sends its waters to Hudson's Bay, and the head-waters of Ondodawanonan River, a tributary of Lake Winibigoshish, through which the Mississippi flows. These junctions are always formed in swamps, some of which are very extensive; and although the amount of water afforded to both the northern and southern streams is sufficient to render them navigable for light canoes in the driest seasons, still in no instance has it been found practicable to conduct canoes, from one stream to the other, through the swamp in which the interlockage is made.

I may also mention here, that, in 1838, I met at Fort Francis, on Rainy River, a Mr. Kane, who had just returned, across the continent, from Fort Vancouver on the Pacific, and was informed by him, that the same lake in the Rocky Mountains gives origin to the Athabasca River, the waters of which are carried to Hudson's Bay, and also to a branch of the Columbia. If this be so, it shows the curious fact of a continuous line of water communication between the very distant points, across the continent, of Hudson's Bay in the north, the Gulf of Mexico in the south, and

the Pacific Ocean, at Astoria, in the west; to which may be added, the Gulf of St. Lawrence in the northeast.

The second variety of lakes are wholly isolated, having no apparent outlet, nor any visible source of supply other than the drainage of the hills which surround them. They are, probably, more numerous than those included in chains, although fewer of them fell under observation, as our routes were generally along the courses of streams. Aside from their want of communication, they differ from the first variety, principally in size, being much smaller. They are most frequently met with in the sections based upon sandstone, or where the country is covered with heavy deposits of drift and clays, resting on metamorphic rocks.

Both varieties of lakes differ greatly in size and configuration; while those of the first variety present almost every possible irregularity of outline, those included in the second variety are generally oval, or circular, or crescent-shaped. Many of the small circular lakes, from a quarter of a mile to a mile in diameter, are from sixty to one hundred feet below the general level, the ground sloping down to the water on every side with great regularity, like the descent of an amphitheatre, and covered with grass.

The lakes are generally shallow, and many of them are dotted with small wooded islands. In several instances, these islands were found to be based upon accumulations of boulders. Those formed by the widening of rivers, or connected in chains, are filled with aquatic plants, many of them containing large fields of the *Zizania aquatica*, the wild oat or northern rice plant. The rice lakes are most liberally distributed in the sections about the head-waters of the Red Cedar, Nemakagon, St. Croix, and Snake Rivers, in the south, and the sources of Big Fork and Red Lake Rivers in the north; and, further east, in the Vermilion Lake region. This grain is an excellent article of diet, and forms a considerable source of support to the Chippewa Indians; many of the bands making annual visits to the rice regions, toward the end of August, for the purpose of gathering a supply for the winter. These fields also attract immense numbers of water-fowl.

The borders of the lakes differ greatly in appearance. Some of them are surrounded by gentle grassy slopes, with occasional trees scattered along them; while others are bordered by extensive marshes, often overrun by the cranberry plant; and again, the shores are rather abrupt, with a dense, dark forest skirting and overhanging the margin. Their beds are generally pebbly, or covered with small boulders, which peep out along the shore, and frequently show a rocky line around the entire circumference. Very few of them have mud bottoms. The water is generally sweet and clear, and, north of the water-shed, is as cool and refreshing during the heats of summer as the water of springs or wells. All the lakes abound with various species of fish, of a quality and flavour greatly superior to those of the streams of the Middle and Western States. The shores of many of them are chosen as sites for villages by the Indians, who show their taste by selecting the most beautiful and picturesque, in sections where the soil is of a quality suitable for gardens.

Although a great number of lakes have been laid down on the map along the lines of observation, still but a faint idea can be obtained, from consulting it, of

their number and distribution. These are matters of considerable interest, in consequence of the influence which the presence of so great an assemblage of waters must exercise on the climate and productions of the region in which they are situated.

The general level of the country, between Lake Superior and the Mississippi, is shown in the profile of the same, the former being taken as a base. These lines of level must be received as approximations only, as, in many instances, time would only allow of one or two barometrical observations being made, for the purpose of ascertaining heights. At most important points, however, the mean of from five to twenty observations was used in making the calculations; and in every calculation the mean of one month's observations, at a single station on Lake Superior, was employed. The following table exhibits the elevations, as determined along some of the lines of observation:—

Section No. 1.

FROM THE MOUTH OF THE CHIPPEWA TO THE MOUTH OF BAD RIVER.

	Feet.
Mouth of the Chippewa,	25
Dalles of the Chippewa (hill top),	722
Chippewa Falls,	403
Vermilion Falls,	307
Brunet's Rapids,	382
Mouth of Lac Courte Oreille River,	493
Lac Courte Oreille (Corbin's Store-House),	581
Lily Lake,	702
Nemakagon Portage,	585
Four miles above Nemakagon Portage,	675
North shore of Long Lake,	721
Alder Creek (portage),	234
Lower Rapids of the West Fork of Bad River,	75
Six miles above Bad River Mission,	54

Section No. 2.

FROM THE MISSISSIPPI, AT ST. PAUL'S, TO THE TRADING-HOUSE ON ST. LOUIS RIVER, EIGHTEEN MILES ABOVE FOND DU LAC.

	Feet.
Mississippi, at St. Paul's,	0
Six miles south of Stillwater,	173
One mile north of Stillwater,	250
Nine miles north of Stillwater,	146
Fourteen miles north of Stillwater,	120
Twenty-two miles north of Stillwater,	122
Top of Trap Dike, nine miles above the Falls of St. Croix,	466
Three miles north of the mouth of Sunrise River,	334
Reed Creek, Pokegoma Trail,	324
Lake Pokegoma,	369
Kettle River, Fond du Lac Trail to Pokegoma,	363
Moose Lake, Fond du Lac Trail to Pokegoma,	319
Horn Lake,	439
Fond du Lac Trail to Pokegoma, eighteen miles south of St. Louis River,	475
Fond du Lac Trail to Pokegoma, two miles south of St. Louis River,	269
Bank of St. Louis River, at Trading-House,	21

Section No. 3.

FROM THE OUTLET OF LAKE ST. CROIX TO THE MOUTH OF BOIS BRULE RIVER.

		Feet.
Outlet of Lake St. Croix (feet below),		7
Table Land at the mouth of Lake St. Croix (feet above),		105
Stillwater, one mile north, on Table Land,	do.	250
Trap Dike, nine miles above St. Croix Falls,	do.	466
Summit, three miles above Sunrise River,	do.	334
Nine miles above the mouth of Kettle River,	do.	304
Thirty miles above the mouth of Kettle River,	do.	443
Hill, one mile north of Pijiki Lake,	do.	596
St. Croix and Brulé Portage,	do.	656
Head of Bois Brulé River,	do.	544
Fifteen miles below the Portage,	do.	415
Third Portage on Bois Brulé River,	do.	373

It will be seen by this table and reference to the sections, that the line of greatest altitude decreases from the eastern boundary of the territory, as the range of highlands is followed westward. This will be still more manifest by referring to the geological section from the mouth of Montreal River to the water-shed. On this section, the elevations are given as far as measurements were made; and it will be perceived that the elevation of the water-shed, on that route, is more than four hundred feet greater than it is between the sources of the Chippewa and the west fork of Bad River, and six hundred and forty feet higher than the highlands between St. Louis River and the Falls of St. Anthony,—the top of the rapids above the Falls of St. Anthony being fifty-one feet higher than the level of Lake Superior.

It will also be seen, by consulting the sections of elevation, that a range of highlands extends along the line dividing the sandy and limestone regions, following the general course of the Mississippi, and crossing the tributaries of that stream from twenty to forty miles above their mouths. Along this line of elevation, the country is generally much lower than along the water-shed; although, at some points, as at the Dalles of the Chippewa, for example, the tops of the highest ridges equal in height the great range directly north of them.

This elevation of the sandy region contributes very much towards modifying the climate of the agricultural district bordering on the Mississippi. The rays of the sun act more energetically in elevated than in low regions; and as the direct influence of the sun is necessary to the germination and perfection of vegetation, and especially of wheat and other grains, the soil of the high limestone district is peculiarly favourable to the growth of such grains. The generally clear and dry state of the atmosphere in midsummer, secures them from blight and mildew.

The distinctive features or peculiarities of the fourth and fifth divisions, as well as of so much of the third as borders Wisconsin River and its sources, will be noticed in the narrative of explorations in those sections of country, and in connexion with their Geology, in Chapter III.

CHAPTER II.

DESCRIPTIVE CATALOGUE OF THE ROCKS REFERRED TO IN THIS REPORT.

WITHOUT a special description of the various beds of rock in the Lake Superior region, from the micaceous and talcose schists up to the latest sandstone deposits, it would be impossible to give anything like an accurate account of the beds of metamorphosed and volcanic rocks, of immense thickness, which are distributed along the Lake shore, between St. Louis River and Pigeon River, and which extend inland as far as the water-shed which separates the waters of Lake Superior from those of Hudson's Bay. And it would be equally impossible to describe, intelligibly, these metamorphosed beds without giving, at the same time, a special description of the various trap dikes, of different composition, and of different ages, by which they are traversed, and which have given rise to the most extraordinary reactions between the sedimentary and intrusive rocks, differing in degree and effect according to their composition, and to the accidents of time and association.

In describing the Geology of the District, then, it will be necessary to describe each rock individually, as it occurs at different localities. Without such specialities we cannot generalize, and without a generalization of all the facts collected, no comparison of this with similar regions can be made, nor can any useful addition to our previous knowledge of such formations be hoped for.

In order to avoid, as much as possible, the frequent repetitions which would otherwise necessarily occur in succeeding chapters, the rocks will be referred to, in the details of sections and localities, by the numbers attached to them in the following catalogue.

In describing the rocks, such terms will be employed as are usually applied by geologists to the same or similar compounds; although it must be confessed that the application would occasionally be found very uncertain, if tried by a systematic rule; for the metamorphosed beds of Lake Superior present almost numberless undefined varieties.

1. Greenstone—gray, compact, fine-grained; occasionally jointed; exposed surfaces iron-shot; presents the general characteristics of the greenstone ridges north of Lake Superior.

2. Metamorphosed siliceo-argillaceous slate—black; minutely granular, with fine glistening points; jointed; resembles some of the basaltic dikes.

3. Clay-slate, much altered, but shows the laminar structure distinctly,—black; no traces of a crystalline structure; no glistening points as in No. 2.

4. Siliceous slate—greenish gray; in near contact with the greenstone dike, is changed to a schistose quartz rock, which, in some of the layers, is granular.

5. Greenstone, coarsely crystalline; weathered surface rough, iron-shot; colour, dark greenish gray.

6. Quartzose sandstone—fine granular; colour, brick-red; resembles some of siliceous schists.

7. Quartzose schist—greenish gray; granular in thin laminæ; resembles the slaty greenstones of Kinuhigakwag Creek. Iron stains between the laminæ, and in the joints. Makes a near approach in some layers to hornblende slate.

8. Clay slate, alternating with the quartzose layers.

9. Hornblendic rock—bedded and jointed like the overlying schists; layers from an inch to an inch and a half thick. Colour, grayish black; minutely crystalline.

10. No. 9, passing into greenstone; more coarsely crystalline than No. 9; but evidently the same rock. Dark greenish gray; compact; weathers with a thin, grayish, iron-shot crust, nearly white externally, contains much yellow iron pyrites.

11. Greenstone.

12. Clay-slate—rusty surfaces between the joints; fracture smooth; lustre dull; no glistening points; no appearance of crystallization.

13. Hornblendic schist—fine grained; bluish green; light gray on exposed surfaces; dark brown in some places; irregularly laminated; in some spots rather compact. Intercalations, of a reddish-coloured jasperoidal rock.

14. Granite—light-coloured, gray, mottled; fine-grained; compact; gneissoid.

15. Hornblendic rock—highly crystalline; green; resembles diallage rock.

16. Same as No. 15.

17. Hornblende rock—coarsely crystalline; dark-coloured, almost black.

18. Slaty hornblende—with seams of iron ore. Some of the beds are siliceous, and resemble the quartzose schists, but are highly ferruginous.

19. Quartz rock.

20. Hornblendic rock—fine-grained; grayish-coloured; resembles No. 16.

21. Syenitic granite.

22. Slaty hornblende—with intercalations of hornstone.

23. Siliceous slate—chloritic.

24. This rock is syenitic in the mass, and should be placed among the granitic rocks. It is composed of quartz and hornblende in about equal proportions. Somewhat fine-grained. It merges into a hornblendic rock.

25. Clay-slate.

26. Syenite—passing into greenstone.

27. Porphyritic greenstone.

28. Hornblendic rock—dark-coloured; fine-grained; crystalline.

29. Slaty greenstone—minutely crystalline.

30. Hornblendic rock—coarsely crystalline; the crystals black and honey-coloured; some quartz; ferruginous.

31. Siliceo-argillaceous slate—would make good roofing and writing slates.

32. Argillaceous slates—very thinly laminated; decomposes easily.

33. Greenstone—very fine-grained.

34. Porphyritic greenstone.

35. Syenite—passing into greenstone, like No. 11, contains flesh-coloured felspar.

36. Hornblende rock.

37. Decomposing hornblende rock.

38. Clay-slate, unaltered.

39. Metamorphosed clay-slate.

40. Hornblende rock, in contact with No. 39; contains Labrador hornblende.

41. Red siliceous porphyry—contains occasional lumps and crystals of quartz; the felspar crystals tabular, red, numerous. Grains of oxide of manganese with an undetermined mineral, are disseminated through the rock in considerable quantity, and also line the joints between many of the felspar crystals, and the embedding paste. The paste is often fine granular.

42. Slaty greenstone—minutely crystalline.

43. Hornblendic rock—resembles the slaty greenstones of Big Fork River.

44. Argillaceous and magnesian slates; very thinly laminated, and easily fractured; colour, gray.

45. Same as No. 44—in close proximity to a dike; metamorphosed; resembles very fine-grained, argillaceous sandstone; coloured greenish yellow by oxide of iron.

46. Hornblendic rock—coarsely crystalline.

47. Calcareous spar.

48. Greenstone.

49. Quartzose porphyry—contains crystals of vitreous quartz, and grains of chlorite (?). It resembles No. 41, but is lighter coloured, more siliceous, less crystalline, and contains fewer disseminated crystals of red felspar, and more of quartz; has a jasperoid aspect in many localities, and in others might be taken for a metamorphosed sandstone. It often bears great resemblance to the baked siliceous shales.

50. Decomposing hornblendic rock, with an earthy aspect; resembling, precisely, burnt clay. Contains many large crystals of hornblende, from one to two inches long.

51. Siliceo-argillaceous slate—much altered by intrusive dikes.

52. Amygdaloid. The base, which is of a dark reddish gray colour, appears to be sedimentary trap. It is somewhat schistose, and fractures easily. The cells contain green earth, calcareous spar, and zeolites.

53. Basaltic rock—colour, black, fine-grained, homogeneous; lustre, dull; fracture somewhat conchoidal.

54. Siliceous slate—highly metamorphosed; rings like phonolite when struck with a hammer, thinly laminated; prevailing colour, reddish gray; very close-grained and brittle.

55. Basaltic rock—fine-grained; almost black.

56. Appears to be metamorphosed clay-slate, or siliceo-argillaceous shale; amygdaloidal; the cells containing calcareous spar and zeolites, with a thin coating of silicate of iron between the sides of the cells and the enclosed minerals. This rock appears to have been fused by the intrusion of No. 55, and the cells formed while in that condition.

57. Same as No. 41; colour, brick-red, laminated; rendered porphyritic principally by crystals of vitreous quartz. Contains numerous grains of oxide of manganese, and probably some chlorite.

58. Hornblendic rock—containing crystals of greenish-coloured felspar.

59. Augitic trap. This is, probably, a diallage rock, with numerous crystals of bronzite disseminated through it. On exposed surfaces, they are copper-red, and in a fresh fracture have a pearly metallic lustre. Before the blowpipe, fuses to a grayish-black enamel.

60. Coarse, porous tufa—looks like fragments of coarsely-pulverised brick, partially fused, and recemented. Very cellular; cavities filled with magnesian minerals. Some of the specimens resemble the finer breccias formed by the breaking up of siliceous shales, and afterwards exposed to great heat.

61. Basaltic trap—spheroidal. The spheroids, which are of a dark gray colour, and homogeneous, are of the size of marbles, and embedded in a light gray, slightly crystalline calcareous rock, which forms, however, but a small portion of the mass, the spheroids greatly predominating.

62. A variety of No. 60, but possesses more of the porphyritic than the amygdaloidal character. Numerous small quartz crystals. Presents the fragmentary character of No. 60, but is compactly and thoroughly cemented by heat. Resembles No. 250, the top rock of the "Great Palisades."

63. Hornblendic rock—colour, black; fine-grained; minutely crystalline.

64. Slaty hornblende—resembles No. 63, but possesses more of the slaty structure; very ferruginous, especially in the joints.

65. Altered sandstone—very fine-grained; micaceous. Resembles some of the beds of Black River.

66. Hornblendic rock—coarsely crystalline.

67. Quartzose porphyry—a more compact variety of No. 62.

68. Hornblendic rock—coarsely crystalline; some of the crystals black; others olive-green. It contains a few fragments and crystals of quartz.

69. Quartzose porphyry—resembles, in all respects, Nos. 41 and 57, except that it contains numerous small irregularly-shaped cavities, filled with many acicular crystals, of a jet-black colour (probably hornblende), which contain manganese.

70. Green and violet-coloured fluor spar, in quartzose porphyry.

71. A variety of greenstone, passing into syenites, with flesh-coloured felspar and black hornblende.

72. Basaltic rock, associated with a reddish-coloured, fine-grained amygdaloid, which is, apparently, an altered clay-slate.

73. Altered clay-slate, resembling, precisely, some of the metamorphosed Devonian slates of Europe; amygdaloidal.

74. Greenstone—fine-grained; minutely crystalline; compact; colour, black. Has the general aspect of basalt.

75. Undetermined. A trappous-looking cellular rock; the joints and cells filled with zeolites. Probably a metamorphosed shale.

76. Metamorphosed sandstone—the rounded grains of quartz distinctly visible; colour, red in some places, dark reddish gray in others. Resembles the quartzites of Wisconsin and Black Rivers. An undetermined green magnesian mineral is disseminated through it, in grains and in cells.

77. Same as No. 76, from which it is separated by some thin seams of finely laminated siliceous material. Contains large nodules of calcareous spar. These two last-named rocks resemble the volcanic grits, and appear to contain a large proportion of volcanic material. The difference in colour depends on the amount of iron in different specimens, and its state of oxidation.

78. Metamorphosed shale—amygdaloidal; many of the cells empty, others filled with laumonite; colour, purple. Shows every evidence of fusion.

79, 80, 81, 82, 83. Metamorphosed sandstone—some of the specimens scarcely altered, others highly metamorphosed, and hardly to be distinguished from trap. In near contact with the next rock becomes amygdaloidal, the cells being filled, principally, with nodules of calcareous spar, which are surrounded with a thin film of chlorite (?).

84. Basaltic trap—in contact with the metamorphosed rock.

85. Basalt. Resembles, precisely, some of the Bohemian basalts, particularly that from Aussig.

86. Metamorphosed sedimentary rock. Bears some resemblance to No. 67. This is probably a fine trap breccia, cemented by siliceous matter, which has been so acted upon by heat as to give it the aspect of quartzite.

87. Jasperoid rock—the joints encrusted with zeolites.

88. Metamorphosed sandstone.

89. Metamorphosed sandstone—amygdaloidal; cells filled with calcareous spar. Less altered than No. 88, and more argillaceous.

90. Metamorphosed siliceous shale—with numerous yellow spots, which penetrate the layers vertically; with wide yellow stripes near the weathering edges. At the partings, exhibits many minute grains of hornblende. Some of the beds are argillaceous.

91. Breccia—cemented by siliceo-argillaceous matter, and burnt into a jasperoid rock. Colour, red; porphyritic. Resembles No. 86.

92. Basaltic greenstone—minutely crystalline; colour, grayish black; columnar.

93. Same as No. 91. Less altered by heat; some of the layers have stripes of a light pink colour. Contains some few water-worn siliceous pebbles. The breccia with which this is connected contains numerous fragments of slate. Some of the beds might, in hand specimens, be called "wacke."

94. Metamorphosed volcanic grit—has grains of a green mineral disseminated through it. Resembles Nos. 90 and 91, but is less quartzose.

95. Volcanic grit—contains felspar, quartz, and hornblende, in grains. It is somewhat syenitic in appearance, but is much less crystalline than syenite. It

would, no doubt, become a regular syenite under the influence of metamorphic agencies.

96. Metamorphosed siliceous shale—colour, red. It is changed to a decided quartz rock.

97. Volcanic grit—very ferruginous; resembles Nos. 94 and 95, but has altered less since its deposition by the action of intrusive dikes.

98. Same as 97. Contains less iron, and is lighter coloured.

99. Volcanic breccia—very amygdaloidal; full of zeolites, principally laumonite; cells irregular. The fragments appear to have been derived from siliceo-argillaceous shale.

100. Metamorphosed siliceo-argillaceous shale—colour, red; hard; brittle; when struck, rings like phonolite; crystals of hornblende, from one-third to half an inch long, sparingly disseminated through it. The mass of the rock is dark brownish red; weathered surfaces lighter coloured.

101. Volcanic breccia—contains small fragments of No. 97. The cement is full of zeolites, principally laumonite. It is very loosely aggregated.

102. Greenstone—fine-grained. The sedimentary rock in near contact with it, can scarcely be distinguished from it.

103. Siliceous shale—thinly laminated; some of the laminæ separated by very thin partings of clay. Colour, dark brownish-red; soft; has a baked appearance; is full of zeolites, which are developed in the partings of the layers and in small cavities. The effect of crystallization in some places has been to break up the thin layers into fragments, so as to give the rock a brecciated appearance.

104. Red sandstone—ripple-marked. These beds cannot be distinguished from those of St. Louis River, or the south shore of the Lake. Colour, light and dark brownish red. Grains small and principally rounded, but there are many angular ones. Lines of deposition marked by black stripes. Some of the beds are highly charged with oxide of iron, and they differ greatly in specific gravity.

105. Same as No. 104, without the ripple-marks.

106. Red sandstone—some of the beds pebbly; the pebbles water-worn; marked by blackish horizontal stripes; a great deal of magnetic iron-sand in the rock, especially in the pebbly parts. The formation of these beds is fully illustrated on the south shore of the Lake, between Poplar River and La Pointe, where sand, pebbles, and iron-sand are being now deposited.

107. Metamorphosed shale and sand-rock—originally the same as Nos. 105 and 106. These beds show almost every degree of metamorphosis. Some contain large druses filled with ferruginous quartz crystals; some are brecciated; others are amygdaloidal; and some are compact. In the amygdaloidal beds the cells are filled principally with calcareous spar. The quartz crystals which line the druses are occasionally encrusted with oxide of manganese.

108, 109. Same as No. 107.

110, 111, 112. Metamorphosed shales and argillaceous sandstone—passes into the purplish red, very compact rock, which rings like clink-stone when struck. Shows the passage of the sand-rock into the argillaceous and siliceous shales of Hat Point, near Grand Portage Bay. The prevailing colour is dark brownish-red; some of the beds are reddish yellow.

113. A very fine-grained, compact rock, of a dark purplish gray colour. Resembles some of the basaltic rocks, but is probably No. 110, in near contact with a trap dike.

114. Volcanic grit.

115. Amygdaloidal greenstone—contains many fragments of prehnite and chalcedony.

116. Breccia—made up of fragments of Nos. 107 and 110, and the associated rocks; amygdaloidal, like all the breccias of this region. The fragments are mostly large, and have been much acted on by heat.

117. Very cellular, the cells mostly empty; when filled, it is with siliceous minerals. Very ferruginous; has an exceedingly rough, jagged fracture. Resembles the scoria from a furnace. It seems to be made up of small fragments of rocks, nearly fused and cemented together.

118. Metamorphosed siliceous shale—amygdaloidal; the cells being filled with an undetermined green-coloured magnesian mineral. This rock appears to belong to the thick earthy beds of the red sandstone series which are to be seen near Cut Face River, and at several places near the west end of Lake Superior.

119. Greenstone—coarsely crystalline; the hornblende predominates.

120. Volcanic breccia—fragments small, and embedded in a fine-grained paste, somewhat trappous in character. Bears some little resemblance to syenite.

121. Trap tufa—overlies No. 120, and is separated from it by about ten feet of metamorphosed shale. Has a somewhat crystalline appearance.

122, 123. Metamorphosed shaly sand-rock—resembles volcanic grit, in some places, and is full of zeolites. Alternates with trap tufa.

124, 125. Volcanic grit—very coarse granular; made up principally of rounded and angular grains of hornblende, with some felspar grains, and a large portion of zeolitic minerals. In general appearance, it resembles some syenites. No quartz grains were detected in it.

126. Metamorphosed siliceous shale—contains numerous minute crystals of hornblende, and some zeolites. Very compact, in general; contains some cells. Is like the rock which underlies the sandstone exposure at "Bark Point."

127. Bedded trap—fine-grained; some of the beds present a laminar appearance.

128. A highly crystalline rock—bedded; some of the beds reddish-coloured, others gray. Made up principally of grains of felspar and quartz, some of the latter the size of a pea.

129, 130. Alternations of trap and metamorphosed siliceous shale. Colour, gray, and dark brown.

131. Basalt—fine-grained; compact.

132. Greenstone—the hornblende predominating; amygdaloidal, the cells filled with scolezite, and probably other zeolites.

133. Dolerite—rather coarsely crystalline; the felspar, which is of the Labrador variety, abundant.

134. Trap tufa(?)—highly crystalline; bears some resemblance to No. 133. Contains numerous crystals of titaniferous iron; zeolites, calcareous spar; some quartz. Hornblende abundant.

135. Volcanic grit—ferruginous; contains a green mineral disseminated through it in grains, and some cavities of considerable size filled with the same.

136. Fine-grained, reddish-coloured trap.

137. Basaltic trap—colour, grayish black; fracture rough, and slightly nodular.

138. Metamorphosed siliceous shale, like No. 110.

139. Resembles No. 138, but is more highly metamorphosed. In some beds, could hardly be distinguished from the slaty greenstones.

140. 141. Volcanic grit and breccia—amygdaloidal in some places, and filled with zeolites; approaches, in general characteristics, the metamorphosed earthy red layers.

142. Volcanic tufa—amygdaloidal, cells numerous, very small, principally filled with zeolites; some of them contain green carbonate of copper.

143. Greenstone—this is most probably a dolerite, like No. 133.

144. Volcanic tufa—containing very large crystals of felspar.

145. Volcanic tufa—colour, dark brown; contains a large percentage of hydrated peroxide of iron.

146. Volcanic grit—colour, purplish gray; minutely granular; numerous grains of a green mineral disseminated through it.

147. Metamorphosed earthy red shale—traversed by veins containing apopholite, Heulandite, calcareous spar, and an undetermined magnesian mineral.

148. Amphodelite rock—highly crystalline; colour, gray and light pink. On a superficial examination, might be mistaken for crystalline quartz rock.

149. Greenstone—rather coarse-grained; crystalline; contains much hematite. In some respects, resembles basalt.

150. Basaltic rock.

151. Volcanic grit—very amygdaloidal; contains a great deal of a green magnesian mineral,* in grains and in cells; colour, reddish gray.

152. Dolerite.

153. Volcanic grit—like No. 151.

154. Same as No. 151. Some of the cells an inch in diameter, and filled with mesole; prevailing colour, reddish gray, but acquires a greenish tint in some places, from the large quantity of green mineral disseminated through it in grains.

155. Volcanic grit—ferruginous; trappous-looking; filled with grains of "green mineral" (thalite). Colour, dark gray, with a tinge of green; in some specimens it pinkish is gray.

156. Jasper.

157. Volcanic grit—made up of felspar, hornblende, quartz, and oxide of iron; minutely granular; some green mineral disseminated through it. General aspect, dark red, with greenish spots.

158. Dolerite—dark-coloured; crystalline, the felspar crystals green; numerous small glistening points.

159. Same as No. 158, but taking on a syenitic appearance. Is made up principally of red felspar, black hornblende, and oxide of iron.

* Since this Catalogue was written, Dr. D. D. Owen has described the mineral alluded to under the name of THALITE. (See *Jour. Acad. Nat. Sci. Phil.*, Vol. II., Part II., 1852.)

160. Same as No. 159—more compact, and finer-grained.

161. Volcanic grit(?)—curiously wrinkled; resembles a mass of cords laid side by side, and cemented together. This rock ought, probably, to be placed among the breccias. Colour, dark red and brown. Fractures so easily between the wrinkles, that it is almost impossible to procure hand specimens of any size. In the mass, it is very hard and compact.

162. Volcanic grit—in near contact with a trap dike. Very rough fracture. Contains a great deal of peroxide of iron and "green mineral" in grains.

163, 164. Volcanic grit—very amygdaloidal; full of calcareous and magnesian minerals; many of the cells filled with the undetermined "green mineral" (thalite?). Colour, red and reddish gray; fracture, somewhat nodular. (See note to No. 151.)

165. Same as No. 163—less amygdaloidal.

166. Volcanic grit—very fine-grained; colour, dark red; differs very little from the ordinary red sandstones which have been subjected to metamorphic influences. Contains prehnite in botryoidal masses.

167. Volcanic grit—amygdaloidal.

168. Dolerite—fine-grained; colour, dark gray, nearly black; compact.

169. Metamorphosed volcanic grit—has a very trappous appearance; colour, dark reddish gray; compact. Has been much acted on by intrusive dikes.

170. Trap tufa—very ferruginous; soft; easily broken down; decomposes into an ochre.

171. Brown hematite—in masses in No. 170.

172. Metamorphosed volcanic grit—same as No. 169. Colour, dark purplish gray.

173. Metamorphosed siliceous shale—very compact; porphyritic; colour, reddish, purplish; resembles the lower part of the "Great Palisade Rock," No. 251. It is rendered porphyritic by decomposing crystals of felspar.

174. Volcanic grit(?)—has a trappous appearance. Seems to have been subjected to the metamorphic influence of several eruptions of trap, subsequent to its deposition.

175. Dolerite—amygdaloidal; fine-grained; colour, dark reddish gray; many small glistening crystalline points.

176. Metamorphosed siliceous slate—somewhat thinly laminated. Same as No. 54, and possesses all its characteristics.

177, 178. Alternations of No. 176, with metamorphosed argillaceous shale; the latter very soft and cellular; the former very hard and compact, like No. 176.

179. Dolerite(?)—basaltic-looking, but minutely crystalline; colour, gray, with a reddish tinge.

180. Metamorphosed shale—amygdaloidal; purplish-coloured; the cells filled with zeolites. Resembles the shale of Cut Face River.

181. Dolerite.

182. Basaltic rock—very fine-grained.

183. Volcanic grit—very amygdaloidal; contains prehnite in cells.

184. Volcanic grit—amygdaloidal; colour, brick-red. The cells contain zeolites and calcareous spar.

185. Metamorphosed shale—very cellular; resembles No. 117, but is not so much altered; the cells are, many of them, filled with zeolites.

186. Volcanic grit—much altered. In general appearance, approaches the eruptive rocks; contains zeolites. Prevailing colour, red.

187. Volcanic tufa—wrinkled like No. 161; amygdaloidal, the cells filled with zeolites; colour, dark brownish red. The original material seems to have been, in part, brecciated.

188. Volcanic grit—highly ferruginous; dark iron-rust colour; fracture irregular, somewhat nodular; is like the ferruginous beds associated with the conglomerates at other localities. Filled with calcareous and magnesian minerals.

189. Same as No. 188, for the most part, but is lighter-coloured, and of less specific gravity, although more compact. It gradually changes, in some localities, to a very compact gritstone, containing nodules of Thomsonite.

190. Same as No. 188. Amygdaloidal; colour, dark red, light red, and reddish gray; fracture, very irregular and uneven; contains zeolites and thalite.

191. Volcanic grit—so filled with grains of the thalite as to give to the rock a green colour, not unlike that of some of the eruptive traps.

192. Same as No. 188. Very ferruginous; amygdaloidal; the grit fine-grained, and of a purplish-red colour. The cells filled with thalite and zeolites.

193. Same as No. 188. Very ferruginous; few amygdules; finely granular; small grains of thalite and zeolites liberally disseminated through the mass; tole-compact. Makes a near approach to the ordinary red sandstones in general appearance.

194. Conglomerate—pebbles of amygdaloid, in a paste of red ferruginous material; the paste amygdaloidal, and resembling the overlying rock, No. 192. Disintegrates easily. Traversed by veins of calcareous spar, and various zeolites, principally laumonite.

195. Siliceous shale—unaltered; very quartzose; fine granular; colour, gray. As the neighbouring trap is approached, the rock takes on precisely the appearance of the quartzites of Black River, Wisconsin River, and other places, as Snake and Kettle Rivers. In some places, small fragments of jasper are disseminated through the rock.

196. Greenstone—same as the Fond du Lac rock, No. 432.

197. From alternating beds of volcanic grit, metamorphosed shale, and, perhaps, metamorphosed sandstone. Some of the beds are compact quartzite.

198. Volcanic grit—amygdaloidal; colour, reddish gray; the cells filled with thalite and many grains of the same disseminated through it.

199. Same as No. 198. Very ferruginous; colour, red; granular; no amygdules.

200. Same as No. 198. More compact, and approaching more nearly to the ordinary red sandstones.

201. Brecciated conglomerate—fragments from one to two inches in diameter; some few larger; generally angular, sometimes rounded; colour, red; amygdaloidal; very hard; brittle; many of them porphyritic, and appears to have been derived from the red quartzose porphyry, No. 251. The paste is lighter-coloured than the

contained fragments, but appears to be derived from the same rock ground to powder.

202. Siliceo-argillaceous shale—highly metamorphosed; prevailing colour, that of well-burnt clay, with yellowish bands, stripes, and spots. The spots, which are oval, are disposed in somewhat regular lines, and connected at their long diameters by very thin lines, which seem to pass through the centres of the spots, and to have been cracks, through which the discolouring agent found its way. The spots pass vertically through the beds. The rock is very thinly laminated; colour of the laminæ, gray, orange, yellow, and red, giving to the edges of the bed a riband-like appearance. Contains small segregations of quartz and of calcareous spar between the laminæ, which are bent around these lumps. At the joints, the rock is discoloured from half an inch to four inches in width. The lighter-coloured laminæ, most of which are very thin, seem to be composed of quartz-sand almost entirely, while the red ones are argillaceous. This rock resembles, in all respects, the base of the "Great Palisades," except in not being porphyritic.

203. Siliceo-argillaceous shale—thinly laminated; highly metamorphosed; colour, light yellow, with thin bluish bands. Over fifty laminæ may be counted in the depth of an inch.

204. Volcanic grit—amygdaloidal; colour, reddish gray; coarsely granular; very ferruginous; contains many grains of thalite.

205. Alternations of volcanic grit and fine breccia—amygdaloidal; contains some water-worn pebbles. Full of zeolites, and carbonate of lime in grains. Colour, light red.

206. Volcanic grit (?)—resembles the metamorphosed earthy sand-rocks; amygdaloidal; fine-grained; colour, dark red.

207. Metamorphosed grit—amygdaloid; fine-grained; ferruginous.

208. Basaltic rock — very fine-grained; homogeneous; colour, greenish gray; numerous irregular accidental joints, both horizontal and perpendicular, seemingly produced by a force acting from below, sufficient to fracture the rock, but not to break it up. These joints are encrusted, all of them, by deep-red stilbite, which gives to a hand specimen, separated at the joints, an almost totally red appearance. In consequence of this rock fracturing most easily at the joints, specimens of any size present an exceedingly fragmentary appearance, not unlike many of the breccias, where the fragments are much harder than the cement.

209. Siliceo-argillaceous matter, minutely granular, and amygdaloidal; brick-red colour; and containing carbonate of lime in small grains. Traverses No. 208, and the metamorphosed rocks, in veins.

210. Veins in No. 208, and the associated rocks. Contains zeolites, calcareous spar, thalite, and fragments of shaly amygdaloid.

211. Metamorphosed siliceo-argillaceous shale very porphyritic, with decomposing crystals of felspar. These beds contain a very fine-grained, dark purplish-gray, basaltic stratum, which is represented by one of the specimens marked No. 211.

212. An aggregate of gravel-stones, small pebbles, and sand, with a great many small pyramidal crystals of quartz; lumps of flesh-coloured felspar, zeolites, and

calcareous spar. Colour, different shades of red and yellow. Has a speckled appearance. Fracture rough and irregular, and harsh to the touch.

213. Metamorphosed siliceous shale—colour, red to purplish gray; hard and flinty; porphyritic, small crystals of red felspar, with lumps and scales of quartz.

214. Greenstone—colour, dark gray, with a greenish tint. Inclined to be prismatic. Tolerably fine-grained.

215. Greenstone—coarsely crystalline; colour, dark green, almost black.

216. Basaltic rock—columnar; columns three to six-sided; granular; colour, dark purplish gray; porphyritic, with a few crystals of felspar; slightly amygdaloidal, the cells containing zeolites.

217. Basaltic rock—very fine-grained; homogeneous; fracture, smooth; colour, purplish gray. Contains a few crystals of felspar, but can hardly be called porphyritic.

218. Volcanic grit—same as No. 188. Colour, reddish-gray; amygdaloidal; cells numerous, large, and filled, principally, with prehnite (var. Thomsonite); some are filled with thalite, and others with several species of zeolite. Small grains of zeolitic minerals and of oxide of iron in the body of the rock.

219. Same as No. 188, in colour, composition, and fracture, presenting a similar nodular surface when broken. In some places, resembles a finely brecciated sandrock; has a highly trappous appearance in others. The material is volcanic, the deposition, sedimentary.

220. Decomposing greenstone—with both Labrador and common felspar; large crystals of hornblende, resembling those found at Gouverneur, New York; weathered surfaces very rough.

221. Slaty hornblende rock—some of it massive, and some tolerably thinly laminated. Colour, very dark gray; minutely crystalline. The massive portion resembles the basaltic rocks, and may, possibly, be an intercalated bed of basalt, modified by its relation to the beds which enclose it. The laminated beds differ very little in appearance from some of the greenstones in which hornblende largely predominates.

222. Argillaceous iron ore, in veins; the sides of the veins lined with stilbite.

223. Quartzose porphyry—resembles, in almost all respects, some of the metamorphosed siliceo-argillaceous shale-beds. Hard; brittle; uneven fracture; colour, dark dull red; felspar crystals, numerous, many of them in a state of decomposition; some quartz in scales and small irregular lumps or fragments of crystals.

224. Probably a basaltic rock—colour, dark brown; fine granular. Some portions of these beds resemble more nearly the metamorphosed siliceous shales. It is columnar, and is underlaid by a breccia, and overlaid by an amygdaloid.

225. Metamorphosed shale—amygdaloidal; colour, red, with spots of an olive-green hue, probably produced by chlorite. Cells filled with zeolites and calcareous spars.

226. From a vein in No. 225. Calcareous spar, laumonite thalite.

227. Metamorphosed siliceo-argillaceous shale; fine-grained; gritty; colour, red. In contact with a trap dike becomes columnar.

228. Dolerite—colour, dark greenish gray; minutely crystalline. Traverses No. 227.

229. Metamorphosed shales—very calcareous; colour, gray; thinly laminated; light specific gravity; granular; contorted. When highly metamorphosed, present a quartzose appearance.

230. Greenstone.

231. Metamorphosed red sandstone—from fragments enclosed in No. 230.

232, 233, 234. Metamorphosed siliceous and siliceo-argillaceous shales—of every grade, from the "Palisade" rock, No. 251, to a light reddish blue and gray rock, little altered. Some are heavy, compact, and fine-grained; others are light and granular; and one variety bears great resemblance to roestone. Some of the beds contain very perfect crystals of Labrador felspar.

235. Basaltic rock—dark-coloured, almost black. A few very minute crystalline points to be seen.

236. Red sandstone—fine-grained; fine lines of deposition.

237. Red sandstone—pebbly; the pebbles from the size of bird-shot to half an inch in diameter, all water-worn, rounded, and smooth.

238. Basaltic rock—fine-grained; homogeneous; smooth fracture; colour, dark purplish gray.

239. Coarse grains of felspar, the size of peas, with a few crystals of larger dimensions, cemented by a paste of dirty reddish-white felspar. Colour, greenish gray. Shows lines of stratification. Appears to have been derived from the disintegration of Amphodelite rock, No. 148.

240. A variety of greenstone—composed, principally, of hornblende and felspar; coarsely crystalline, with a few crystals of white felspar disseminated through it, which gives it a porphyritic appearance.

241. Greenstone—minutely crystalline.

242. Same as No. 195. Siliceous shale; colour, light purplish gray; some thin white bands of sandy material; a few white spots, which penetrate the rock perpendicularly; very fine-grained; fracture smooth, the perpendicular one even, the horizontal one, in the thicker layers, conchoidal.

243. Same as No. 242—with thin partings of quartz-sand.

244. Metamorphosed argillo-siliceous shale—colour, red, like a half-burnt brick; the lamination discoverable, but nearly obliterated. Tolerably large grains of quartz disseminated through it. Not so highly metamorphosed as the rock underlying the "Great Palisades," but belongs to the same beds.

245, 246. Coarse siliceous shale—becomes coarsely granular, and then pebbly, and finally merges into a coarse conglomerate, with many large pebbles of Nos. 242 and 243, from half an inch to three inches in diameter. The shaly, pebbly portion is of a purple colour, thinly laminated, and full of zeolites between the laminæ and in the joints; and has small veins or strings of laumonite ramifying through it in all directions. It bears a great resemblance to the shale-beds intercalated with the upper conglomerate of St. Louis River.

247. Dolerite—colour, dark greenish gray; disposed to be prismatic at some points.

248. Basaltic rock—colour, grayish black; very fine-grained; homogeneous; no appearance of crystallization; contains veins of calcareous spar.

249. Calcareous spar—from a vein in No. 248; the sides of the vein lined with a hard, yellow material, derived, probably, from decomposed felspar.

250. Metamorphosed siliceo-argillaceous shale—colour, purplish; very rough, uneven fracture; porphyritic, like No. 251. In some places presents the appearance of a fine breccia, well cemented by material of the same character as the fragments.

251. Siliceo-argillaceous shale—highly metamorphosed, and changed to a quartzose porphyry. The beds are the same as No. 244. Contains numerous crystals of felspar, mostly four-sided prisms, and in a decomposing state; and also many grains and incrustations of oxide of manganese.

252. Metamorphosed siliceous shale—finely laminated; colour, purplish red; porphyritic; numerous prisms of decomposing felspar, and some few of quartz; very hard and brittle.

253. Basaltic rock—fine-grained; fracture, smooth; colour, greenish black.

254. Breccia—made up of fragments of sandstone and shale, and strongly cemented; colour, dark red; full of cells and cavities, which contain mostly calcareous spar, and a green incrusting mineral, probably silicate of iron.

255. Same as No. 254, but not so much altered.

256. Basaltic rock—fine-grained; black, with a reddish tint.

257. Basaltic rock.

258. Basaltic rock. Same as No. 256.

259. Brecciated conglomerate—composed, principally, of fragments and pebbles from the amygdaloidal beds of volcanic grit, and the earthy red shale-beds; mostly angular, but with many rounded ones. These are cemented together by earthy matter which has been partially fused. The cement is amygdaloidal, and contains carbonate of lime with some zeolites. Colour, dark purple, and mottled. Has been subjected to a high degree of heat.

260. Same as the conglomerate No. 246, and the coarse siliceous beds (No. 245) associated with it. Some of the shale-beds appear to have slipped over one another, producing a planished surface, with numerous green stains, produced, probably, by silicate of iron. A good deal of chlorite(?) is found in the body of the rock, in streaks and in small cavities. Bears great resemblance to the green schists of St. Louis River.

261. Basaltic rock—colour, dark purple; homogeneous; very compact; fracture smooth. At some points the basalt has penetrated the sedimentary deposits for some distance, and shows itself in small patches.

262. Same as No. 251 and No. 41 of Pigeon River. This rock, which, at the contact of the two, takes on the character of No. 261, is composed of numerous lumps and crystals of red felspar, cemented by quartz, and on smooth surfaces, presents a highly porphyritic appearance. The predominant colour of the whole rock is deep flesh-red. I consider it to be the same as the "Great Palisade" Rock, and to have been altered from the siliceous and argillo-siliceous shales so well developed on the Wisacodé River. The rock is highly crystalline, and the degree of metamorphosis is probably the highest of which it is susceptible.

263. Belongs to the same series as No. 262, but was derived from more earthy beds. Resembles hornstone at some localities, and quartzite at others. Thin edges of small fragments translucent.

264. A still more earthy bed of No. 262—very amygdaloidal; cells small, oval, and filled with zeolites and calcareous spar. Colour, purplish red.

265. Greenstone—colour, dark gray, nearly black; crystalline; the hornblende predominating.

266. Siliceous shale—same as Nos. 195 and 242; altered, but bearing all the characteristics of those rocks.

267. Same as No. 266—highly metamorphosed. Some of the beds are very compact, highly crystalline, and of a pinkish-gray colour, resembling, in general aspect, some of the quartzites, especially in near contact with the trap dike. Occasionally presents the appearance of the top beds of the "Great Palisades," containing small lumps and scales of quartz, which render it porphyritic.

268. Siliceous shale—quartzose; colour, gray; somewhat altered; otherwise does not differ from the shales of "Hat Point," below Grand Portage Bay.

269. Same as No. 268, in all respects.

270. Same as No. 268, but much metamorphosed. Colour, reddish gray; very hard; some of the layers flint-like; in some places, loses its gritty appearance, and has a smooth, even fracture across the laminæ, but is still granular between the layers. It is precisely like the base of the Palisades, except in not being porphyritic.

271. Highly metamorphosed siliceous shale—colour, grayish-red; fracture smooth in one direction, somewhat splintery in another; very hard; has a dull waxy lustre, like pitchstone; in some places, the rock could not be distinguished in hand specimens from the quartzites of Wisconsin; in others, it is like jasper. Belongs to the same beds as No. 270.

272. Anorthite rock—coarsely crystalline; colour, greenish and greenish white, with some crystals of flesh-coloured felspar. A very few small crystalline fragments of hornblende are found in it at some spots. In the forceps, fuses to a white glassy bead full of blebs.

273. Same as No. 271, in contact with No. 272—jasperoid.

274. Greenstone—hornblende predominates; colour, nearly black; coarsely crystalline. Weathers with a rough surface, the felspar disintegrating fastest.

275. Syenitic greenstone—a good deal of flesh-coloured felspar in it. Minutely crystalline; weathers with a tolerably smooth, rusty surface; fracture rough.

276. Greenstone—coarsely crystalline; colour, dark greenish gray; contains some patches and strings of flesh-coloured felspar; weathered surface rough, and rusty-coloured; the joints filled with magnesian minerals.

277. A variety of greenstone—composed partly of hornblende, but mostly of felspar, which fuses, in small splinters, to a clear glass (sometimes a blebby one) like 272, but is much more difficult to fuse. Coarsely crystalline; colour, black and greenish yellow, as one or other constituent prevails. Weathers with a rough surface.

278. Greenstone—coarsely crystalline; hornblende predominates; colour black,

with a tint of grayish green. In some places, contains flesh-coloured felspar. Weathers with a slightly rough, iron-shot surface.

279. Greenstone—colour, grayish black; the felspar honey-coloured, some of the crystals large; some large crystals of hornblende.

280. Greenstone—very coarsely crystalline.

281. Decomposing crystals of hornblende in a felspar paste.

282. Siliceo-argillaceous shale—highly metamorphosed; colour, dark purplish gray; thinly laminated; same as No. 100; rings like phonolite when struck. Is associated with basaltic beds; joints contain stilbite.

283. Syenite (?)—colour, flesh-red; highly crystalline; the felspar predominates; weathers slowly, and with a tolerably even surface. Differs little, if at all, from the highly metamorphosed beds of No. 213.

284. Greenstone—colour, very dark gray, almost black; minutely crystalline; the hornblende predominates.

285. Siliceo-argillaceous shale; highly metamorphosed; colour, brick-red; very compact; fine-grained; almost homogeneous; resembles jasper; contains a few small lumps and scales of quartz; fracture uneven; weathers with a smooth surface; no incrustations; very hard. Some of the beds are less compact, and inclined to be shaly.

286. Basaltic rock—colour, dark gray, almost black; is jointed, and shows a laminar structure; a thin crust of iron rust between the laminæ, and in the joints; is generally homogeneous, but exhibits, in some places, minute crystalline points. Weathers with a smooth, black surface. This rock is separated from No. 287, by beds of amygdaloid.

287. Volcanic grit—colour, reddish gray, with a slightly greenish tint; fine-grained; tolerably compact; many grains of thalite (?) disseminated through it. This rock bears considerable resemblance to some of the altered sandstones. Contains numerous grains of peroxide of iron.

288. Metamorphosed siliceo-argillaceous shale—colour, brownish red; amygdaloidal, the cells filled with zeolites; has a very rough, hackly fracture; shows evidences of thin lamination, rendered indistinct by metamorphic action.

289. Metamorphosed shaly sand-rock, or volcanic grit (?)—colour, brick-red; slightly amygdaloidal; contains a few rounded siliceous pebbles.

290. Metamorphosed sand-rock—colour, grayish red; compact; contains many minute crystals of yellow iron pyrites. Belongs to the finer grit beds.

291. Basaltic rock—fine-grained; colour, dark gray, with a slightly reddish tint.

292. Argillaceous iron ore.

293. Basaltic rock—fine-grained; colour, dark purplish red; fracture, smooth, conchoidal; nearly homogeneous; has a few minute crystalline points.

294. Metamorphosed siliceo-argillaceous shale; colour, red; fracture, sharp, uneven; very hard; has a baked appearance; contains occasional small crystals of felspar. Resembles the "Great Palisade" rock. In contact with No. 293.

295. Same as No. 294—less compact; shaly; has a greater resemblance to the quartzites. The less altered portions show a granular structure.

296. Basaltic rock—colour, purplish gray; homogeneous; fracture, slightly irregular.

297. Greenstone—highly crystalline; contains a few flesh-coloured crystals of felspar; colour, very dark gray, with a bluish tint. Weathers with an iron-shot crust.

298. From a vein traversing No. 294—contains small pebbles, calcareous spar, zeolites, and green earth.

299. Metamorphosed siliceous shale—colour, greenish gray; some of the beds gritty. Contains organic impressions, like those found in the altered shales of Passabika River.

300. Conglomerate—the paste containing calcareous spar and green earth.

301. Basaltic trap—like No. 296.

302. Metamorphosed siliceous shale—amygdaloidal in some places; in general, but little altered.

303. Greenstone—like No. 297.

304. Metamorphosed siliceous shale—colour, red; resembles, somewhat, the top rock of the "Great Palisades;" has a jasperoid appearance.

305. Hornblende rock—highly crystalline.

306. Greenstone—finely crystalline; contains many small crystals of red felspar; the hornblende predominates.

307. Basaltic rock—colour, greenish gray; very fine-grained.

308. Metamorphosed argillaceous shale—amygdaloidal; the cells few, and containing zeolites; colour, gray, with a greenish tint; compact; irregular conchoidal fracture.

309. Porphyry—the paste hornblendic, and filled with large crystals of felspar; colour, dark gray; very crystalline; the felspar crystals tabular.

310. Basaltic rock—colour, dark gray, almost black; resembles the dolerites, and may belong to that variety of greenstone.

311, 312. Varieties of No. 309.

313. Basaltic rock—colour, dark purplish gray; fracture, uneven.

314. Basaltic rock—decomposing into an ochre; colour, red; fracture, nodular; amygdaloidal; cells few, and filled with carbonate of lime and zeolites; very ferruginous.

315. Volcanic grit—overlies No. 314; its material derived in part from that rock; ferruginous; incrustations of iron rust in the joints.

316. Metamorphosed siliceous shale—colour, deep red; very fine-grained; contains organic impressions like those of No. 299.

317. Metamorphosed argillo-siliceous shale—contains numerous horizontal black stripes; has a trappous appearance.

318. Metamorphosed shaly sand-rock—resembles No. 317 somewhat; amygdaloidal; the cells being filled with thalite.

319. Dolerite—compact; massive; fine-grained; colour, dark greenish gray.

320. Basaltic rock—colour, dark greenish gray; the joints contain chlorite and stilbite; fine-grained; homogeneous; fracture, irregular and uneven.

321. Metamorphosed argillaceous shale—of a dirty black colour, with numerous dark green spots, probably chlorite; slightly amygdaloidal. Contains pebbles of other rock.

322. Metamorphosed volcanic grit, or sand-rock—colour, reddish gray; rough granular fracture; amygdaloidal, the cells filled with round grains of thalite, of a nearly white colour; very ferruginous.

323. Volcanic grit—very amygdaloidal; the cells filled with zeolites; colour, light gray, with a reddish tint. Presents, in the mass, a curious mottled appearance.

324. Volcanic grit—more compact than No. 323, but still amygdaloidal; colour, dark grayish red; contains grains of thalite.

325. Volcanic grit—hard; compact; slightly amygdaloidal; colour, red; contains grains of thalite.

326. Very coarsely crystalline greenstone—the hornblende predominating; colour, black.

327. Greenstone—similar to No. 326.

328. Anorthite rock—colour, greenish gray, gray, grayish pink, pink, flesh-red, sea-green; some of the crystals olive-green. Massive; highly crystalline; fracture, uneven, lumpy, jagged, smooth. Resembles quartz in its general aspect, and might be mistaken for it on a superficial examination. Lustre vitreous; transparent, translucent, subtranslucent, to opaque; streak, white; lustre of some of the crystals inclining to pearly. In the forceps, fuses easily to a transparent glassy bead, full of blebs. Weathers with a smooth whitish or gray surface, and without forming an incrustation.

329. Greenstone—same as No. 327.

330. Greenstone—colour, dark gray; finely crystalline; fracture uneven; weathers with an iron-shot crust.

331. This rock resembles syenite in general appearance, but is composed of Labrador hornblende and white felspar, with a great deal of stilbite disseminated through it, in small aggregations and crystals. The red stilbite, the black hornblende, which is beautifully iridescent, and the white felspar, each being in separate aggregations, combine to form an extraordinarily beautiful rock.

332. From a vein. Contains prehnite, calcareous spar, laumonite, quartz, and earthy green carbonate of copper.

333. Greenstone—highly crystalline; colour, dark gray; felspar, white and yellowish white.

334. Metamorphosed siliceo-argillaceous shale—colour, dark purplish red, with occasional dark green spots and stripes, probably due to chlorite; very fine-grained; hard; fracture, irregular, and somewhat splintery. Resembles one of the metamorphosed beds of Kinechigakwag Creek.

335. Siliceous schist—very quartzose; colour, gray, with a greenish tinge; metamorphosed; resembles some of the slaty greenstones in general appearance.

336. Greenstone porphyry—reddish-coloured crystals of felspar, embedded in a greenish-coloured paste of light-coloured felspar and hornblende.

337. Greenstone.

338. Metamorphosed sand-rock—colour, brick-red; tolerably fine-grained; contains small sandstone pebbles; carbonate of lime, some zeolites, and a great deal of iron-sand.

339. Amygdaloid—a dark purplish red, earthy rock, full of elongated oval cells; the cells all pointing in their long diameter, in the same direction, and very much compressed vertically. The cells are mostly filled with laumonite. Probably the same as No. 364. Belongs to the earthy beds of the lower sand-rock series.

340. A light-coloured calcareous rock—near the igneous rocks becomes cherty, and the fracture splintery; occurs in patches in No. 339, rather than in beds of any great extent. Resembles No. 414.

341. Metamorphosed shaly sandstone—colour, brick-red; fine-grained; tolerably compact; jointed; the grains round and cemented by iron, with some calcareous material; numerous grains of magnetic iron-sand; occasional small aggregations of laumonite.

342. Veins—containing argillite and earthy magnesian material, with joints incrusted with oxide of iron.

343. Greenstone—colour, dark green, almost black; minutely crystalline. Contains a good deal of yellow iron pyrites, and some prehnite in lumps.

344. Earthy green carbonate of copper.

345. Metamorphosed sandstone—very fine-grained; colour, like that of an overburnt brick; very compact; in thin beds; jointed.

346. Metamorphosed siliceous and argillaceous shales, alternating with thin beds of basaltic rock. The shales are fine-grained, with many grains of chlorite (?) disseminated through them; colour, purplish gray, with a tint of green. Some of the beds are slightly amygdaloidal, the cells containing siliceous minerals.

347. Basaltic rock—from the beds in No. 346.

348. Slaty greenstone—colour, dark gray, laminated; jointed; fracture irregular, lumpy. Like some of the shales of Kinechigakwag Creek.

349. Slaty greenstone—same as No. 348. Merges into dolerite.

350. Greenstone—colour, greenish gray; finely crystalline.

351. Clay ironstone—striped with very thin laminæ of a deep blue colour; seams lined with calcareous spar.

352. Argillaceous slate—same as that of St. Louis River and Pigeon River.

353. Amygdules, from one to three inches in diameter, containing laumonite;—from an amygdaloid interposed between Nos. 346 and 347. The laumonite is surrounded by a capsule of small quartz crystals, which are united at their intersections by siliceous matter. Calcareous spar is occasionally associated with the laumonite.

354. Basaltic rock—very fine-grained; colour, grayish black; non-crystalline; homogeneous; has a rough, irregular, nodular fracture. In some spots, contains very minute grains of a green mineral. Bears a great resemblance, in all respects, to the basalt of Aussig, in Bohemia.

355. Hornblendic slate—very compact; jointed; tolerably thinly laminated; colour, gray and reddish gray. Surface between the laminæ and in the joints, stained of a dirty yellow colour, by oxide of iron.

356. Metamorphosed sandstone—fine-grained; slightly amygdaloidal, the cells filled with thalite; colour, red.

357. Metamorphosed siliceo-argillaceous shale—colour, dark gray, with a purplish tint; fine granular. In some places has a basaltic look.

358. Metamorphosed red sandstone—fine-grained; compact; colour, dark purplish red. Some of the seams and joints are bluish-coloured, like cracks in an overburnt brick. Same as No. 356, but more highly metamorphosed.

359. Volcanic grit—colour, dark purplish red; numerous grains and lumps of thalite. Has an irregular nodular fracture; ferruginous. Weathers with a smooth, brownish-red surface.

360. Metamorphosed earthy sand-rock—slightly brecciated; very irregular fracture; amygdaloidal cells filled with a green mineral, probably chlorite; and the same mineral is distributed through the rock in patches. Colour, reddish gray, spotted with green; fine-grained. Has rather a shaly structure in some places.

361. Metamorphosed sand-rock—colour, dark reddish brown; very compact; fine-grained; rough, irregular fracture. Less altered than No. 360.

362. Greenstone—colour, greenish gray; minutely crystalline; amygdaloidal, especially near the rock which it traverses; the cells contain zeolites, sometimes surrounding a nucleus of calcareous spar.

363. Metamorphosed quartzose shale—colour, dark gray; tolerably thinly laminated; contains small nodules of crystallized quartz.

364. Metamorphosed earthy sand-rock—colour, grayish red; amygdaloidal, the cells filled with zeolites. Some of the beds are soft, disintegrate easily, and resemble baked clay.

365. From a vein—contains fragments of rock, calcareous spar, some zeolites and rock crystal.

366. Red sandstone—white bands; very fine-grained.

367. Native copper—associated with quartz and zeolites.

368. Hornblendic slate—same as No. 355.

369. Native copper and malachite, in quartz. The vein also contains large masses of prehnite, some laumonite, and other zeolites.

370. Anorthite rock—colour, in hand specimens, greenish yellow; in the mass, greenish black; highly crystalline, many of the crystals half an inch long, and some of them longer. Fuses to a white enamel. Some portions of the rock contain a few grains of hornblende. Same as No. 328.

371. Basaltic rock—colour, greenish black; non-crystalline; fracture smooth, disposed to be conchoidal. Weathers with a smooth, even surface, covered with a very thin greenish scale.

372. A seam in No. 370. Decomposing felspar, filled with large grains of quartz, and hardened into a very compact rock. Colour, yellow, with numerous dark points, made by the quartz and a few grains of hornblende.

373. Veinstone—granular quartz, containing native copper.

374. Native copper, associated with prehnite, laumonite, calcareous spar, quartz, and some undetermined zeolites.

375. Metamorphosed sandstone—colour, reddish gray; fine-grained; very compact. Resembles the sandstones of the upper part of St. Croix River.

376. Metamorphosed argillaceous sandstone—colour, purplish gray; fine-grained; smooth, even fracture; contains a few siliceous nodules, surrounded with a film of chlorite, spots of which are also disseminated through the rock.

377. Brecciated conglomerate—reddish-coloured; amygdaloidal; the cells contain a good deal of laumonite; many of them are empty, the sides being incrusted with chlorite. The fragments and pebbles appear to have been derived from the earthy beds of the sand-rock series.

378. Metamorphosed earthy sand-rock—amygdaloidal, cells filled with decomposing laumonite; colour, purplish red; fracture, exceedingly irregular and rough; looks almost as rough as a fine, well-cemented breccia. The fragments of No. 377 were derived from beds of the same character.

379. Similar to No. 378—harder; less amygdaloidal; fine granular, like No. 375. Corresponds with the soft earthy beds of St. Louis River.

380. Similar to No. 378—amygdaloidal; shaly; contains numerous green spots of the size of peas, probably chloritic. Resembles some specimens brought from an island near Pigeon Bay.

381. Metamorphosed shale—colour, dark gray; contains a great deal of chlorite (?) in grains and small lumps; schistose; roughly laminated; rough surfaces between the laminæ; fracture, lumpy; very calcareous. Mixed, apparently, with basaltic material. Like some of the beds of Kinechigakwag Creek.

382. From a vein in No. 381—prehnite, incrusting siliceous minerals, and in reniform nodules.

383. Basaltic rock (?)—colour, black; fine-grained; minutely crystalline; fracture uneven; numerous iron-stains. In some places, looks as if it had been partially splintered, and recemented with the same material, or a more ferruginous one.

384. Metamorphosed siliceous shale—colour, light pink, with a greenish tint, caused by numerous minute grains of chlorite (?); fracture smooth, granular, disposed to be conchoidal. Weathers with a smooth surface.

385. From a vein—prehnite, massive, and in botryoidal incrustations; some laumonite; malachite and black oxide of copper in small cavities.

386, 387. Metamorphosed siliceous and siliceo-argillaceous shales, alternating—colour, dark brownish red to bright red; very hard and compact; fine-grained; smooth, conchoidal fracture; porphyritic, with small crystals of flesh-coloured felspar; slightly amygdaloidal, the cells containing minute quartz crystals, and a few crystals of a mineral supposed to be chlorite (?).

388. Earthy amygdaloid—colour, dirty red; very cellular; most of the cells are empty, but some of them contain laumonite; the cells are compressed vertically, as though the beds had been subjected to heavy pressure before the rock was solidified. This crushing in of the cells has given a brecciated appearance to the beds, and this may have been the case with some of the brecciated beds at other places. The rock is very earthy, and appears to have been a mud bed, more or less metamorphosed at different places. The fracture is exceedingly rough and hackly. Its

porosity renders it very light. Longer-continued or more energetic metamorphic agency, would probably have converted it into a rock like No. 117.

389. A vein in No. 388—quartzose, granular; colour, dirty yellowish gray; fine-grained; a good many grains of felspar, and many of a green colour, too small to be determined; has a banded appearance on fractured surfaces. A few small gravel-stones are contained in it.

390. Metamorphosed sandstone—but little altered; colour, red; like the fine-grained argillaceous beds of the south shore of the Lake. Contains nests of quartz crystals.

391. Dolerite—very fine-grained; minutely crystalline; colour, very dark gray. Weathers with a smooth, light-gray surface, covered with a thin crust. Sometimes the weathered surface is black.

392. Basaltic rock—colour, gray; homogeneous; shows no appearance of crystallization; fracture, even, inclined to be conchoidal.

393. A seam at the junction of Nos. 390 and 391—contains angular fragments of No. 391, the interstices being filled with calcareous spar and zeolites. One side of the seam appears to have been rubbed smooth by a vertical motion.

394. Amygdaloidal nests in No. 390—the cells filled with globular and kidney-shaped nodules of calcareous spar, the nodules being incrusted with a thin coating of green carbonate of copper. Some of the cells are filled with carbonate of copper, and a few grains of the same mineral are scattered through the base of the amygdaloid.

395. Tourmaline—in nests in No. 390; colour, brown and brownish red; in long crystals, penetrating calcareous spar. Many of the crystals are green externally.

396. Quartz crystals—in druses in No. 390; some of them are large, and all are incrusted with oxide of iron.

397. Epidote—associated with calcareous spar; in metamorphosed sandstone conglomerate.

398. Vein in metamorphosed sand-rock—resembles No. 389. Contains native copper and prehnite, with numerous grains of native copper disseminated through it. The veinstone is quartzose.

399. Has a syenitic appearance—but is probably a volcanic tufa; colour, red; is made up of fragments of felspar and hornblende crystals, enveloped in a very calcareous paste.

400. A tolerably fine-grained calcareous rock—highly metamorphosed; resembles aphanite; contains fragments of clay-slate.

401. Metamorphosed siliceo-calcareous shale—amygdaloidal; colour, purplish gray; belongs to the amygdaloidal earthy beds. The cells are filled with carbonate of lime in kidney-shaped nodules, with a thin coating of chlorite next the sides of the cells.

402. Argillo-calcareous shale, highly metamorphosed; amygdaloidal; cells numerous, and filled with carbonate of lime; colour, purplish gray; decomposes easily, when exposed to the weather. This rock is associated with a syenitic-looking tufaceous porphyry, which contains much flesh-coloured felspar, in irregular, fragmen-

tary, crystalline lumps, and much epidote, with a dark olive-green mineral, supposed to be chlorite.

403. Basaltic rock—colour, reddish gray; fine granular; contains numerous grains of epidote and chlorite.

404. Metamorphosed siliceo-argillaceous shale—calcareous; colour, light red, with bluish-gray spots; joints lined with carbonate of lime; body of the rock filled with grains of the same mineral. Has the appearance of having been baked.

405. Same as No. 404—colour, reddish yellow; siliceous; becomes quartzose in the vicinity of intrusive dikes; granular; fracture uneven.

406. Metamorphosed sandstone schist—numerous grains of epidote and of iron pyrites disseminated through it.

407. Same as No. 404—more highly metamorphosed, and more compact; colour, bluish gray and reddish yellow. All these schists are calcareous, and their specific gravity increases with the increase of metamorphosis.

408. Basaltic rock—colour, dark reddish gray, almost black; contains much iron pyrites; effervesces with acids.

409. Metamorphosed shale—calcareous; very compact; colour, reddish yellow; fracture smooth. Is rendered porphyritic by the dissemination of a few crystals of flesh-red felspar.

410. This rock bears some resemblance to the volcanic grit beds, but more to the quartzose porphyries of the Wisaçodé River. Is porphyritic; contains disseminated crystals of felspar and hornblende; in the mass, presents a granular appearance. Colour, flesh-red, with numerous black dots made by grains of magnetic iron. Contains some small pebbles and fragments of slate.

411. Breccia—derived from the sand-rock beds; very cellular; contains large quantities of epidote; general colour, dark brick-red; contains fragments of felspar, and numerous grains of magnetic oxide of iron; slightly calcareous.

412. From nests in No. 404—contains calcareous spar, fluor spar, and epidote.

413. Greenstone—massive; colour, dark gray; crystalline.

414. Calcareous beds—contain epidote, calcareous spar, laumonite, fluor spar, and green earth. Under the influence of trap dikes, these beds become cherty. See No. 340.

415. Fine granular quartzose shales—much bent and contorted; colour, greenish gray. Contain numerous fucoidal impressions.

416. Greenstone.

417. Greenstone—very fine granular.

418. Slaty greenstone—thinly laminated; interstratified with beds of schistose quartz rock.

419. Metamorphosed siliceous shale—colour, brownish red. Resembles No. 176.

420. Basaltic rock—very fine-grained.

421. Metamorphosed earthy schistose rock—porphyritic.

422. Basaltic rock—colour, dark gray, with a purplish tint; slightly porphyritic.

423. Slaty greenstone—grayish-coloured; very calcareous; amygdaloidal. Contains epidote and small particles of native copper.

424. Metamorphosed clay-slate—has a basaltic appearance in the vicinity of trap dikes.

425. Greenstone—slaty. Bears considerable resemblance to hornblende schist.

426. Porphyritic greenstone—coarsely crystalline; bears great resemblance, at some points, to petrosilex.

427. Basaltic rock—colour, grayish to black, with a light tint of red; fine-grained.

428. From a vein—contains calcareous spar, some zeolites, and numerous small fragments of rock. This vein is situated between the walls of a trap dike and the sedimentary rock.

429. Vein—contains calcareous spar, yellow iron pyrites, and fragments of rock.

430. Vein—contains calcareous spar, zeolites, and sulphate of barytes.

431. Dolerite—fine-grained; minutely crystalline.

432. Greenstone.

433, 434. Greenstone.

435. Slaty greenstone—grayish-coloured; amygdaloidal, the cells filled with zeolites; contains much epidote in grains and amygdules. Some of the beds very quartzose, and might be set down as quartz-rock.

436. Greenstone.

437. Metamorphosed shaly sandstone—reddish-coloured; amygdaloidal, the cells filled with epidote. Resembles some of the grits in the neighbourhood of Inaonani and Kawimbash Rivers.

438. Sandstone—somewhat shaly; colour, light gray, with a reddish tint, derived from numerous grains of red felspar; more quartzose than the overlying beds; harder; more compactly and firmly cemented. On the under surface of one of the beds are numerous casts of shrinkage cracks, from a mere line to an inch in width, and an inch deep. In some places, there are casts of cavities in the underlying rock, from six to eight inches in diameter, and an inch and a half in depth, exhibiting impressions of pebbles. The casts of the shrinkage cracks radiate in all directions from the casts of the cavities or hollows just mentioned. The under surface of this layer, together with the casts, are covered with a thin parting of bluish-green clay, loaded with minute scales of mica. Calcareous.

439. Very fine-grained shaly sandstone—colour, light red, with yellowish bands.

440. Shaly sandstone—is more compactly cemented, and presents more of a slaty appearance than Nos. 438 and 439; colour, grayish green; somewhat micaceous; ferruginous on the surfaces; calcareous.

441. Conglomerate—made up almost entirely of rounded pebbles of quartz, of all sizes, from that of a pea up to six inches in diameter, with a few fragments of chert, and an occasional pebble of argillaceous slate; the whole firmly cemented by a yellowish siliceous paste, highly charged with oxide of iron, and containing numerous grains and fragments of iron pyrites mingled with coarse sand. The cracks and fissures in this rock are filled with iron pyrites. Fractures pass through the pebbles without deviation. Prevailing colour, gray.

442. Conglomerate—consisting, principally, of pebbles of quartz, cemented by calcareo-siliceous matter, somewhat ferruginous, with small argillaceous white-

coloured particles sparingly disseminated through it. It also contains many pebbles of red shale and green argillite. The rock breaks easily in the course of the cement, the pebbles being liberated from their matrix without injury. It is a finer conglomerate than No. 441, few or none of the pebbles exceeding an inch in diameter. Colour, reddish.

443. Red slaty sandstone, in thin layers, with occasional yellow bands; fine-grained; separates easily in the direction of the laminæ. Between some of the layers thin bands of coarse gravel, well rounded and polished, and consisting mostly of quartz and argillite. In the lower beds, as No. 441 is approached, the rock becomes more schistose, is of a greenish-gray colour, and consists, principally, of coarse sand, and quartz-gravel and pebbles, with sulphuret of iron disseminated in fragments and grains, all firmly cemented with clay and oxide of iron. The rock is distinctly laminated, and separates easily in the direction of the laminæ. The cross fracture is rather smooth, passing through the pebbles and gravel-stones with as much facility as through their matrix. In the lowest beds, near the junction of the underlying rock, the various constituents are less firmly united, and the joints and partings are of a dark iron-rust colour.

444. Argillaceous sandstone—extremely fine-grained; colour, dark red; numerous minute whitish dots disseminated through it. The upper surface is covered with small protuberances, about an inch long and one-third of an inch wide, all pointing in the same direction and overlapping one another, giving to the rock a somewhat mailed appearance.

445. Shaly sandstone—with pebbles and stripes of green argillaceous matter; very fine-grained. Resembles No. 674, but is whiter and unaltered.

446. Siliceous shale—with thin layers of small pebbles or gravel, mostly of quartz and slate; no trap pebbles.

447. Siliceous shale—colour, reddish to brown, with yellowish bands; fine-grained.

448. Argillaceous slate—colour, dark gray, with a reddish tint, becoming reddish brown or chocolate-coloured on the weathered surfaces and in the joints. Some portions of it are dark green on the surfaces of the joints, some of which are smooth, and have a polished appearance; there are numerous green stains, with a thin film of talcose matter, and the structure of the rock presents a fibrous appearance. It contains a few grains of oxide of iron.

449. Argillaceous schist—colour, green; compact; contains numerous grains and crystals of iron pyrites. It is not fissile, splitting only in the direction of the joints, and then imperfectly. Between some of the joints there is a thin talcy coating. The structure is fibrous throughout, so much so, as to lead to the supposition that the constituents of the whole mass of rock, when in a plastic condition, have, in consequence of a tilting force, slipped over one another, the harder grains of iron pyrites leaving minute furrows and markings in the direction of the dip, which being filled with the finer material, produced the fibrous structure alluded to. The green colour is probably due to chlorite.

450. Argillaceous slate—colour, dark blue and grayish blue; very fissile, and

easily divisible into thin laminæ; very fine-grained; homogeneous; magnesian. It might properly be called a talcose argillaceous slate.

451. Same as No. 450—colour, gray and greenish gray; very thinly laminated, with thin scales of talc between the laminæ. It has an eminently soapy feel, and, in some of the beds, might be set down as talcose slate. It is easily scratched with the nail, which leaves a white streak. It is traversed by veins of No. 452.

452. White crystalline quartz, with particles of flesh-red felspar, crystals of carbonate of lime, and nodules of iron pyrites.

453. Argillaceous slate—colour, grayish blue; very compact, so much so as to lose almost entirely its fissile character. The marks of fine lamination, however, are never entirely obliterated, and, occasionally, the rock can be split with difficulty in the direction of the laminæ. The fracture is somewhat splintery. In some of the joints it is discoloured by iron-stains, but in other cases the joints become grayish white, under the influence of atmospheric agents. The texture is even and fine-grained.

454. Greenstone—colour, grayish black; the hornblende predominates largely; fine-grained; minutely crystalline; resembles the dolerites.

455. Greenstone—colour, grayish; amygdaloidal; the cells, which are numerous, contain quartz, epidote, copper pyrites, and some zeolites. In structure and colour, it resembles the greenstone trap of Black River.

456. Greenstone—massive; tolerably fine-grained; the felspar of a honey-yellow colour, in grains and in crystals; colour, dark greenish gray, with a yellowish tint. Weathers with a rough iron-shot crust.

457. Red sandstone conglomerate, precisely like those of the north shore of Lake Superior, which have been subjected to metamorphic influences. The prevailing colours of the materials are red and gray; and, like the Lake Superior conglomerates, it has many zeolitic and other minerals developed in small cavities and interstices. The larger pebbles are mostly of sandstone, some of them much altered. It contains a few greenstone pebbles.

458. Sandstone—fine-grained; colour, from dark pink to deep brownish red; very ferruginous; grains round and angular, mostly angular; many minute glistening points, which appear to be crystals of calcareous spar. Felspar grains seem to predominate.

459. Metamorphosed red sandstone—tolerably fine-grained and compact. It contains occasional cells filled with thalite. In its general characteristics it resembles No. 485, and many of the rocks on the north shore of Lake Superior. It is, probably, a volcanic grit.

460. Metamorphosed siliceous shale. This rock resembles many of those on the north shore of Lake Superior, and particularly some of the slaty beds of Kinechigakwag Creek. (See No. 425.) A portion of the beds is a trap breccia, containing much epidote; while other beds are porphyritic, and contain many fragments of flesh-coloured felspar. In the mass, it might be set down as a slaty greenstone.

461. Greenstone—colour, greenish gray; fine-grained; crystalline.

462. Red sandstone—fine-grained; compact; flesh-coloured; contains small lumps of ferruginous clay.

463. Red sandstone, striped with white bands.

464. Same as No. 463, but lighter-coloured, more compact, somewhat micaceous, and having large grains of quartz disseminated through it.

465. Conglomerate. In the upper part the pebbles consist of quartz and chert, cemented by siliceous matter. The pebbles vary in size from that of a pea to a walnut. Colour, red.

466. Conglomerate—from a bed forty feet below No. 465. Besides quartz and chert pebbles, it also contains many of clay-slate.

467. Same as No. 462, but darker-coloured.

468. Sandstone, in contact with amygdaloid—colour, reddish gray; extremely compact, passing into quartzite. Intersected by numerous seams of quartz.

469. Amygdaloid—derived from the siliceo-argillaceous beds of the sandstone series. Colour, dark red; cells filled with calcareous spar. Contains nodules of jasper.

470. From a vein in the amygdaloidal. Consists of a clayey substance, mixed with siliceous matter, coloured by chlorite.

471. Greenstone—colour, grayish green; coarse granular fracture; hornblende, the predominant constituent.

472. Altered sandstone—fine-grained; quartzose; colour, dark gray.

473. Greenstone trap (?)—compact; coarse, uneven fracture; somewhat fibrous or striated; numerous seams lined with hornblende; colour, grayish green. (This may be a metamorphosed sedimentary rock.)

474. Metamorphosed argillaceous slate—colour, dark brown; irregular fracture; contains seams and incrustations of calcareous spar.

475. Same as No. 474, but more compact, and somewhat siliceous.

476. Amygdaloid — tolerably compact; irregular fracture; contains but few amygdules, filled with chlorite; colour, brownish red. Passes into No. 477.

477. Amygdaloid—contains numerous cells filled with some zeolitic minerals, and nodules of calcareous spar, incrusted with earthy chlorite.

478. Greenstone—colour, dark greenish gray; compact.

479. Greenstone—colour, dark gray; compact; uneven fracture.

480. Red sandstone; fine-grained; siliceous; compact; colour, light red, with white stripes.

481. Sandstone—colour, yellowish red; fine-grained; siliceous; the seams mottled with white and dark red spots.

482. Copper ores from "Plummer's Mine"—consisting of the sulphuret, and green and blue carbonate; the carbonates being the predominant ores. They occur mostly in the form of incrustations, and in grains interspersed through the sand-rock. The sulphuret is in very small particles, and mostly disseminated through the sand-rock, like the carbonates.

483. From the beds of metamorphosed shales and sandstones at "Plummer's Mine."

484. Quartzite—metamorphosed sandstone, resembling those of the Wisconsin and Minnesota Rivers, and of the Falls of Pokegoma, on the Mississippi.

485. Same as No. 484; but of a darker red colour. Contains patches of chlorite, and irregular lumps of flesh-coloured felspar.

486. Metamorphosed siliceous shale — colour, dark reddish brown; fracture, uneven, shaly; fine granular. Resembles the siliceous grits of the clink-stone type on the north shore of Lake Superior.

487. Same as No. 486. More highly metamorphosed; colour, brownish red; fracture, smooth and even; subporphyritic; contains patches of chlorite.

488. Gray oxide of copper, with earthy green carbonate.

489. From a vein at Dr. Borup's mine—epidote and quartz. Some of the epidote is crystallized, and some is massive.

490. From a N. 5° E. dike—colour, purplish red; very fine-grained; contains streaks and patches of chlorite; weathered surface, iron-shot; great specific gravity.

491. Greenstone (?)—colour, gray; numerous small green points, made by grains of hornblende. This rock resembles the shaly greenstones of Kinechigakwag Creek, and may possibly be a sandstone, metamorphosed by contact with a dike, which is only twenty-five feet distant.

492. Metamorphosed sandstone—colour, reddish gray; crystalline.

493. Syenitic granite—tolerably fine-grained; felspar predominant, flesh-coloured.

494. Gneiss—fine-grained; colour, gray.

495. Syenitic gneiss—with pale reddish felspar, and black mica; traversed by granite veins.

496. Coarse quartzose granite, in large veins.

497. Syenite—colour, reddish, in consequence of flesh-coloured felspar predominating.

498. Syenite—felspar, white; hornblende predominates, giving a dark appearance to the rock.

499. Hornblende rock—a compact compound of quartz and hornblende, the former predominating; very fine-grained; fracture uneven, inclining to splintery; colour, gray.

500, 501. Quartzose veins in No. 499, with nodules and seams of hornblende and iron pyrites.

502. Hornblende rock—very compact; colour, gray; uneven fracture; grains of iron pyrites disseminated through the rock.

503. Porphyritic syenite—flesh-coloured felspar, giving a reddish hue to the rock; quartz and hornblende equally divided; irregular fracture; felspar predominates.

504. Syenitic granite—felspar predominant, and flesh-coloured; tolerably fine-grained.

505. Gneissoid rock—colour, dark gray; graduates into mica slate.

506. Slaty hornblende—fine-grained; colour, light green.

507. Micaceous clay slate—very fine-grained; the mica thinly disseminated; colour, grayish green.

508. Siliceous slate—colour, gray; very hard; fracture, splintery; minute grains of iron pyrites sparsely disseminated through it.

509. Talcose slate—quartzose; contains some mica and felspar; laminæ, rather indistinct; colour, grayish green; fracture irregular.

510. Talcose slate—very fine-grained; compact; thinly laminated; colour, grayish green; suitable for whetstones.

511. Quartz—colour, reddish brown; crystalline; with yellow iron pyrites, crystallized as well as foliated, disseminated through it.

512. Micaceous quartzose schist—very fine-grained; inclining to a fibrous texture.

513. Fine-grained mica slate—thinly laminated.

514. Same as No. 513—traversed by veins of fine-grained granite.

515. Fine-grained mica slate.

516. Mica slate—coarse-grained; traversed by granite veins.

517. Granite—fine-grained; passing into syenite; colour, grayish and greenish.

518. Mica slate—colour, grayish black.

519. Mica slate—shows an inclination to a more granular structure than No. 518; colour, gray, and brownish gray; the disposition of the scales of mica does not affect the granular appearance of the mass, although mica is the predominant mineral; fracture, irregular; incrustations of oxide of iron among the scales of mica, and the fragments of felspar and quartz.

520. Mica slate.

521. Granite—fine-grained; colour, grayish white; felspar predominates; the quartz and mica being quite subordinate.

523. A compound of felspar and quartz—coarsely granular; colour, yellowish brown; irregular fracture; traversed by seams of quartz.

524. Granite—passing into syenite; flesh-coloured felspar predominates; sometimes rich in mica; in general, fine-grained; colour, pale red, and gray.

525. Coarse felspathic granite—the felspar flesh-coloured.

526. Gneiss—the felspar, pale reddish in colour; black mica predominant; passing into

527. Fine-grained mica slate, with minute crystalline grains of felspar.

528. Mica slate—fine-grained.

529. Mica slate—coarse-grained.

530. Granite—rather felspathic; colour, reddish, from the predominance of flesh-coloured felspar.

531. Porphyritic granite—the felspar base red, in which mica and crystals of white felspar are embedded; contains but little mica; rather coarse-grained.

532. Mica slate—very finely laminated; colour, gray.

533. Very coarse felspathic granite.

534. Vein, containing very large crystals of flesh-coloured felspar, associated with quartz.

535. Fine-grained mica slate.

536. Fine-grained mica slate, traversed by veins of felspar of a dirty white colour.

537. Felspar, from a vein in No. 536; contains garnets, and some little black mica.

538. Graphic granite—containing nests of actinolite, and some tourmaline. The actinolite is radiated, the crystals very fine, and of a white colour, playing into

greenish, with the lustre of silk. The tourmaline is ruby-coloured, and appears in minute crystalline masses, disseminated through the actinolite.

539. Mica slate.

540. From a vein traversing mica slate—very coarse, with plates of silvery mica largely predominant. The mica slate is perfectly studded with garnets.

541. Talcose slate, containing numerous quartz crystals.

543. Gneissoid granite—coarse-grained; colour, gray.

544. Granite—very coarse-grained, with large crystals of felspar, and large plates of yellow and brown mica.

545. Mica slate—dark brown mica predominant.

546. Mica slate—traversed by grains of felspathic granite.

547. Greenstone—colour, gray; crystalline; coarse granular fracture; very tough; weathered surface, iron-shot.

548. Gneiss—very fine-grained; structure, a little inclined to slaty; colour, from light to dark gray; traversed by veins of granite.

549, 550. Same as No. 548.

551. Mica slate—the felspar, red, giving a reddish tint to the rock, passes into gneiss, and the gneiss into No. 552.

552. Granite—coarsely crystalline; white felspar and black mica.

553. Gneiss—fine-grained; the felspar predominant; dark brown mica, traversed by granite veins. Passes into No. 554.

554. Very fine-grained mica slate.

555. Greenstone—fine-grained; compact; fracture conchoidal.

556. Greenstone—very fine-grained; structure slaty.

557. Greenstone—colour, gray; numerous small specks of white felspar; the weathered surface of a lighter gray colour than a fresh fracture.

558. Greenstone—colour, greenish gray; porphyritic; the embedded crystals are albite. This is a beautiful rock, and resembles some of the Bavarian porphyries.

559. Slaty greenstone—tolerably fine-grained; colour, greenish; graduates into mica slate.

560. Mica schist—passing into mica slate; colour, gray.

561. Greenstone—very compact; even fracture; colour, light green; in some places inclines to a slaty structure.

562. Mica slate—very fine-grained; colour, gray; structure occasionally fibrous.

563. Greenstone—colour, light green; compact; fracture rough.

564. Greenstone—colour, dark green; compact; rough fracture; sometimes shows a slight disposition to a slaty structure.

565. Gneiss—fine-grained; felspar, flesh-coloured and predominant; mica, black.

566. Hornblende slate—compact; sometimes amygdaloidal; colour, green; might be called variolite.

567. Hornblende slate; fine-grained; no amygdules, and darker coloured than No. 566.

568. Porphyritic greenstone—colour, very dark green, almost black; hornblende greatly preponderating, giving the rock a nearly black colour.

569. Greenstone—fine-grained; but breaking with a rough, almost hackly fracture; colour, light green.

570. Greenstone—coarsely granular; colour, grayish green; irregular fracture; in some places porphyritic.

571. Syenitic rock—resembling hypersthene; coarsely granular; subporphyritic; irregular fracture; fresh fracture, greenish-coloured; weathered surface, brownish black; grains of iron pyrites sparsely disseminated through it.

572. Syenite—felspar largely predominating; light-coloured; hornblende in small crystals. Resembles syenite from the Simplon, in the Alps.

573. Syenitic granite—a coarse-looking gray rock, with white felspar, which is subordinate to the hornblende.

574. Hornblende rock—composed of quartz and hornblende; colour, nearly black, from the great preponderance of crystalline hornblende.

575. Quartzose gneiss — dark-coloured; stained with numerous ferruginous blotches.

576. Granite — felspar predominant, and of a pale flesh-colour; mica, black; deeply stained with oxide of iron.

577. From a granite vein in No. 575—contains but little mica; the felspar largely predominating, and of a pale flesh-colour. Appears to be the same rock as No. 576.

578. Same as No. 574, but more nearly resembling greenstone.

579. Granite—rather coarse-grained; dark-coloured; composed of minute crystals of hornblende, quartz, black mica, and flesh-coloured felspar.

581. Resembles No. 574—finely crystalline; the quartz predominates, however, and gives the rock a gray colour.

582. Syenite—colour, grayish; composed of extremely small grains of hornblende, quartz, and felspar.

583. Quartz and flesh-coloured felspar, the felspar predominating; coarse-grained.

584. Granite—fine-grained; highly crystalline; the felspar red, and the mica black.

585. Altered sandstone, approaching to quartzite; colour, red.

586. Quartzite—a highly metamorphosed sandstone; colour, purplish red.

587. Limestone—containing a Murchisonia of the Silurian type.

588. Bears N. 30° E. Very fine-grained—almost homogeneous. Colour, dark gray; jointed. The joints present a polished, shining, black surface, with, in some cases, the lustre of crystallized hornblende, and have a greasy feel. It may be called basaltiform greenstone. This is the first rock at the Entry Point. Between many of the joints, the surface is iron-shot. Magnetic.

589. Bears N. 45° E. Greenstone. Colour, greenish gray. Crystalline. Weathers with an even surface; contains small grains and crystals of yellow iron pyrites. The felspar white and greenish-coloured. Weathered surface lighter-coloured than a fresh fracture.

590. This rock, which is in contact with the trap rocks, and might be classed among the syenites, is, undoubtedly, a metamorphosed one; and was derived, probably, from the siliceo-argillaceous beds found between the Entry Point and Fond

du Lac, and on Portage Creek. Colour, reddish gray. It appears to be composed of hornblende, quartz, and flesh-coloured felspar; the last-named constituent so predominant as to give colour to the rock. The hornblende and quartz are granular; the felspar in small segregations. In general aspect, it bears great resemblance to the altered sandstones found on Black River, the Wisconsin, and on the Mississippi. It weathers with a very rough surface, is cavernous, and slightly nesty. It is compact, heavy, and breaks with a regular fracture.

591. Bears N. 14° W. Porphyry. The base seems to be granular felspar and magnetic oxide of iron. The embedded crystals are numerous, and of a dirty white and light flesh-colour. The base is of a dark colour, and has a rough, irregular fracture. It is very compact, and, except in colour, bears strong resemblance to the "Great Palisade" rock. It is an overlying rock at the second point below the "Entry Point," and occupies, no doubt, the same place in the series as the Palisade and other siliceous porphyritic rocks of the middle and easterly portion of the District, which rocks have been placed among the metamorphosed siliceous and argillaceous slates. This is the same rock as No. 421 of the Kinechigakwag Creek series, and as No. 590, though this last is not magnetic. These porphyries are magnetic, and contain a great deal of epidote in the joints, and probably some chlorite disseminated through them. The dip at the place where this specimen was taken is 18° S. E. No. 591 is jointed, and some of the joints present a rusty colour. Weathers with a smooth surface. Is traversed by No. 592. The trap is magnetic, and the probability is, that the dike has conferred no property on the metamorphosed rock which it does not itself possess. This rock comes to the Lake again in the third bay east of the Entry Point, where it seems to bear N. 45° E. This change of dip is, no doubt, owing to the difference in bearing of the intrusive rocks.

592. Bears N. and S. Basaltic greenstone—homogeneous; very fine granular. Colour, very dark gray-black, on the weathered surface, which is smooth and even; joints with a thin coat of iron-rust. It is slightly magnetic. This is the character of most of the narrow dikes in this vicinity.

593. Porphyry—like No. 591. Has less of the trappous appearance; is very compact; numerous crystals of deep flesh-coloured felspar; some few small segregations of the same. Would make a beautiful rock for ornamental purposes. It is magnetic, like No. 591. Has a tolerably even fracture. Weathered surface smooth, the paste and embedded crystals seeming to wear equally. Contains some epidote. Belongs to the Kinechigakwag Creek beds. It is possible that No. 591 may be a narrow dike, through which much of the material of this rock was erupted, and may bear an analogy to the Anorthite rock in the region of the Palisades. The paste, which is very fine, has a dark reddish tint, and contains numerous minute grains of magnetic oxide of iron, in which respect it bears a strong analogy to some of the fine-grained argillaceous grit beds. It is magnetic.

594. Bears N. 30° E. Greenstone. Rather more coarsely crystalline than No. 589. Colour, grayish green. Some of the felspar green; some of it inclined to a flesh colour. Is jointed; one set of horizontal joints dipping regularly to the S. E.; another set, W. 15° N.; and a third set, N. and S. These last are perpendicular. Has an irregular fracture. Iron-shot in the joints, and partially so on weathered

surfaces. Resembles the N. 45° E. dikes more than any others. Very heavy. Magnetic. In the second bay, and the points of third and fourth bays, below the "Entry Point."

595. Metamorphosed shale. Traversed by numerous joints and cracks; the joints containing partings of calcareous and magnesian minerals in their scales. Colour, greenish gray; general tint, greenish, like the green slate of St. Louis River. Very fine-grained; contains small pebbles of a soft, green-coloured magnesian rock, like itself. Numerous minute dark points, arranged in lines or strings; which may be chlorite, but are, most probably, as the rock disturbs the needle, magnetic oxide of iron. It is easily fractured, breaking into irregular rhomboidal masses. It is traversed by joints, so that it is almost impossible to procure a fracture by which the structure of the rock can be seen. In some places it is very fissile, but dividing irregularly, and into rather small, scaly-like fragments. It is distinctly fine granular, and resembles, a good deal, some of the specimens about "Hat Point," and particularly some of the slaty beds of Prince's Bay and Spar Island. This rock is traversed by a number of narrow N. and S. dikes, like No. 592; and in immediate contact with some of these dikes, this rock is converted into No. 596.

596. This rock is of a bright brick-red colour; very hard; crystalline, and, seemingly composed, in great part, of felspar. On a horizontal fracture, it has a granular appearance; the grains being mostly red, with numerous black or greenish black grains disseminated through it. On a cross fracture, the red felspar seems to be arranged in minute acicular crystals, from the sixteenth to one-eighth of an inch long, and radiating from points. Cracks filled with very thin seams of a mineral, which is probably quartz. In this respect, the rock resembles the lower Palisade. This rock appears to be highly felspathic, and differs, originally, in composition from the mass of the green shales.

597. Bears N. 45° E. A very dark brownish-red trap. Very ferruginous. Does not disturb the needle. Crystalline; composed of felspar, hornblende, and iron. It bears some resemblance to No. 596, but has, probably, been derived from the great greenstone dikes, and is an overflow, bedded among the schists, and subsequently altered by later dikes, along with the schist and marl-beds, which have reacted on it. It weathers with a dark red, rusty surface, but does not scale. I am uncertain whether to collate it with No. 596, or with the greenstones. (See No. 599.)

598. Bears N. 10° E. This is a fine-grained greenstone. Colour, grayish green; jointed; joints with thin sheets of carbonate of lime traversing them. In some parts, the structure is almost homogeneous. Approaches more nearly to the bedded shaly rocks of Kinechigakwag Creek and Big Fork River, which I have called "slaty greenstone," than any of the other systems of dikes. This is a narrow dike, well exposed, and easily traced on the Lake shore.

599. This rock is traversed by the dike No. 598, and the specimen which was taken from the junction is exceedingly hard and compact; of a deep brick-red colour; and seems to be composed, in most part, of deep flesh-coloured felspar, like No. 596; and from its analogy to No. 599, I am inclined to the opinion, that they may all, probably, belong to the same beds, and should be placed with or near to

No. 593, or to the Palisade beds. The specimen is precisely like the specimens taken from the arch at the Great Palisade. Weathered surface, polished.

600. Bears N. 45° E. Basaltiform trap. Colour, grayish black. Very fine granular; homogeneous; compact. Joints with carbonate of lime in thin seams. Weathered joints, with a thin, dirty yellowish coating. Weathers like the Basalt of Aussig, in Bohemia. This rock differs entirely in structure and appearance from the N. 45° E. dikes of greenstone, of which No. 589 is a specimen. It resembles more nearly some of the N. and S. dikes. It probably belongs to an older period, as it is traversed by a N. 30° E. dike a short distance below Passabika River. The fracture of this rock is disposed to be conchoidal, and its weathered surface is smooth.

601. Basalt—bears N. 30° E. Narrow; traverses No. 600 in the middle of the second bay below Passabika River. Resembles this last rock so much that it would be difficult to distinguish them in hand specimens. The joints appear to contain epidote. Weathered surface, smooth, black, and somewhat greasy to the feel.

602. Metamorphosed rock—has a syenitic look, and is composed of deep flesh-coloured felspar and magnetic iron, with, probably, some hornblende, though this last mineral is not very obvious. It affects the magnet powerfully. The iron is in grains and segregations. These beds are associated with No. 595; and are, no doubt, the same as No. 593. It presents a semi-crystalline appearance; has a rough, irregular fracture; and the colour is that of the red felspar, which predominates over the other constituents; the large grains of magnetic iron give it, however, a mottled appearance. It weathers with a smooth, irregular surface, the irregularity being caused by the iron disintegrating more easily than the felspar.

603. Bears N. 30° E. This is a dolerite—and compares exactly with a specimen of dolerite, from Sternheim, near Hanau, in Germany. Colour, dark bluish gray, with a greenish tint. Fine granular; homogeneous; joints, rusty; magnetic. On the weathered surface, numerous grains of magnetic oxide of iron may be detected. Fracture, somewhat irregular and rough. This dike, which is a wide one, is believed to traverse a N. 5° E. one. It disintegrates easily; and the metamorphosed rocks traversed by it have their joints and cavities filled with zeolites. It crosses Rivière des Françaises, near its mouth, and at its junction with the metamorphosed rocks in the bed of that stream; contains nests and druses of copper ore, and some native copper. The greenish tinge is due, probably, to the dissemination through it of epidote, in minute particles. As the mouth of Rivière des Françaises is approached, the trap becomes amygdaloidal. This occurs near its junction with the sedimentary rocks.

604. Breccia—at the junction of No. 603, with the sedimentary rocks. The fragments derived mostly from the shaly beds. Very cavernous; the cavities being filled with zeolites, principally laumonite. Some carbonate of lime and copper ore. Fragments exceedingly rough, irregular, and jagged.

605. This is a metamorphosed shale; but bears some resemblance to some of the N. 5° E. narrow trap dikes. It is enclosed in No. 603, in both large and small fragments. No dike is to be seen of this character at this place, and as it resembles the metamorphosed shales on the Lake shore, near the mouth of the Brulé, I class

it among them. It is of a purplish-red colour, with numerous dark-green spots disseminated through it. Very fine-grained and compact, with a tolerably smooth fracture. Weathers with a polished, dark brownish-red surface. Magnetic.

606. Veins of massive epidote, from one to two inches thick, traversing No. 603 on the Lake shore, a short distance below the mouth of Rivière des Françaises.

607. Basaltic trap—bears N. 5° E. Fine granular; homogeneous. Colour, purplish gray; joints, rusty-coloured. Bears considerable resemblance to No. 601, but differs in colour, and in being slightly amygdaloidal. Contains small nodules of chalcedony. The cells, which are few and small, are filled with a dark olive-green mineral, probably chlorite. The rust in the joints is a dark bright red. Weathers with a smooth, even surface, of a reddish-brown colour. Magnetic. Traversed by No. 603 (?), and traverses No. 588.

608. Bears N. 15° W. Greenstone—colour, greenish gray; somewhat rough, irregular fracture. Feebly magnetic. Has numerous grains of sulphuret and peroxide of iron disseminated through it. The green grains and crystals of this rock bear considerable resemblance to hypersthene, but it is so fine-grained, that it cannot be determined by the eye. Traverses No. 588.

609. Bears E. and W. This specimen is from the grit-beds which lie against an E. and W. basaltic dike. It is the same as No. 359. It is very ferruginous, and full of a green mineral. It is very fine granular, has a nodular fracture, and is feebly magnetic. It has been derived from the dike No. 354. It is, probably, a true volcanic tufa or gritstone, formed by materials deposited either at the time of the eruption, as an overflow, or immediately after that period, from the wearing down of No. 354. No. 359 is very magnetic.

610. Amygdaloid. The base is reddish gray—very fine granular; and belongs, probably, to the volcanic grit-beds No. 609. It is remarkably cellular—the cells being small, and filled with a soft white mineral, which does not effervesce with acids, probably stilbite (?). It may be called a toadstone. Bears N. 30° E.

611. Bears E. and W. Traverses No. 610. This is a basaltic rock, like No. 609, and is a dike, with a well-defined wall on one side. (The other side could not be examined.) It is red, contains a great deal of iron; is fine granular, and contains a great deal of a zeolitic mineral in small grains and in a few cells, the size of large peas. Has a nodular fracture. It is possible that this rock may be a portion, like the overflow, or may have been a deposit along the margin of the dike during the eruption of No. 354. It is also the same with No. 189, brought from Two Island River. It is difficult to say whether these rocks are due to sedimentary action or not. All analogy, however, seems to indicate that they are deposits of erupted material. Very ferruginous. Feebly magnetic. The iron appears to be mostly in the state of peroxide. Weathers with a smooth, red surface. Contains numerous small scales of mica (?).

612. Basalt—colour, dark greenish gray. Very fine granular; homogeneous. It is very compact, and contains no accidental ingredients.

613. Bears N. 45° E. Greenstone—coarsely crystalline. Colour, greenish gray; the hornblende occasionally in large crystals, with a lustre like black glass; the felspar, mostly green. This rock, which is massive, bears great resemblance to the

"Nepheline Rock" of Löbau, in Saxony. It cannot be distinguished from it in hand specimens, and probably contains either nepheline or elæolite. It also contains a mineral having the characteristic appearances of Olivine. It cuts through all the rocks in this locality. It bears a much greater resemblance to some of the dolerites, as No. 603, for example, which bears N. 30° E., than it does to the greenstones which have the same bearing with itself. If placed among the greenstones, it should be put down as a basaltic variety.

614. Metamorphosed rock. Has the appearance of a fine breccia; the fragments small and recemented by oxide of iron. The rock appears to have been derived from the beds of the Palisade series, probably the upper part. Colour of the fragments, gray; but the rock has a reddish, mottled appearance, in consequence of the colour of the cementing material. It has a very peculiar, lumpy appearance, as though the sedimentary rock had been broken into innumerable small fragments, but without much displacement. Cleavage planes or planes of lamination are still very obvious. It contains numerous irregular cavities, from half an inch to an inch in diameter, and compressed in a line with the planes of lamination. These cavities are filled with steatitic mineral; the central portion of a dirty white colour, and an external coating of a greenish-brown colour. Fracture, exceedingly irregular and lumpy. Disturbs the needle very feebly. Belongs to the felspathic bedded rocks.

615. Bears N. 45° E. Colour, greenish black. Belongs to the basalts, and might be called a basaltic greenstone. Crystalline; the crystals small and not very obvious. An occasional large crystal of green felspar. Contains numerous aggregations of mica in rounded masses, the scales arranged in radii, and proceeding from a black centre. The aggregations are about half an inch in diameter, the black centre about one-eighth of an inch, and then the plates assume a yellow colour, with metallic reflections, bright, and sometimes of a coppery hue. This yellowish part forms a ring around the black centre, about one-eighth of an inch wide, and beyond this the plates become black like the centre, and are lost in the rock. This mica is transparent, inelastic, brittle, sectile, foliated. B. B. it fuses easily in the forceps to a white enamel; intumesces; and, in some instances, the enamel is blebby. This rock is probably the same as No. 613. This appears to be the newest dike at this place, and in some parts shows a decidedly columnar structure. This may be seen at the point on the main shore, opposite Encampment Island. Magnetic.

616. Anorthite rock—highly crystalline. Colour, dark gray. Has much the aspect of quartz. Has all the characteristics of No. 328, differing only in colour. This specimen shows its contact with a basaltic dike, in which immense fragments of it are embedded, and from one of which the specimen was taken. The dike is magnetic, while the anorthite rock is not.

617. Bears N. 45° E. This is a very fine-grained trappous rock, resembling, a good deal, the fine-grained greenstones, and especially those of a slaty character. It also bears a great likeness to the metamorphosed siliceous shale-beds of "Hat Point," as well as to those of a similar character on Kinechigakwag Creek. It contains a great deal of magnetic oxide of iron, in grains and crystals. It is almost homogeneous. The weathered surface is very light gray, nearly whitish, with numerous minute black points of oxide of iron. The felspar is white, and weathers

more slowly than the other ingredients. Its composition is best seen on weathered surfaces. See No. 291.

618. Bears N. and S. Very fine granular, apparently homogeneous. Colour, purplish gray. Fracture, quite even; disposed to be conchoidal. Very compact. May be compared with Nos. 400, 401, 419, and 427. It is a bedded rock, at several points, and is, in all probability, a metamorphosed rock; and if so, belongs to the fine-grained siliceous slates. There is no appearance of crystallization about it. On the other hand, it seems to cross Kanokikopag River, in the form of a dike, and does bear some resemblance to the narrow N. and S. dikes of other localities. Magnetic. It is very heavy, and my opinion is, on the whole, that it is most like the trap, in general aspect, but like the sedimentary rocks in structure. It breaks into rhomboidal prisms.

619. Metamorphosed siliceo-argillaceous slate. Colour, brick-red, with occasional small spots of a deeper brownish red, due to segregations of oxide of iron. Very compact. Has a very even fracture. Resembles some of the highly-altered quartzites. Jointed; some of the joints lined with highly-crystalline quartz. For a short distance on each side of the joints, the rock is discoloured, being of a light yellowish red. These beds contain large rounded pebbles of a greenish-coloured siliceous shale, very much like the green shales of St. Louis River; and around these pebbles is a ring of lighter colour than the body of the rock, like that which is next the joints and incrustations of vitreous quartz. This rock resembles closely No. 599, and may be compared with No. 635, and also with No. 621 and No. 596.

620. This rock is like No. 609, No. 188, and No. 359. It belongs to the volcanic grit-beds. Colour, purplish gray. Very fine granular; numerous grains and scales of the soft magnesian mineral (thalite). Fracture, nodular; irregular. Is allied to the basaltic rocks, in so much as the principal materials were derived from them either during or immediately after the eruption of basalt. Magnetic.

621. Fragments of No. 620, in a N. and S. dike, below the mouth of Kanokikopag River. It differs from No. 620 only in being rather more indurated, of a darker colour, and in the development of small segregations of red felspar, and of small crystalline lumps of quartz, as are shown in the Great Palisade rock at some places, giving it a porphyritic appearance. This specimen contains patches of a lighter colour (reddish gray), which show neither felspar nor quartz segregations, and some of which appear to have been pebbles derived from older beds of a similar rock. The same is the case with No. 620. Magnetic.

622. Bears, apparently, E. of N. Syenite. This rock is composed of lumps of quartz, flesh-coloured felspar, and hornblende, the last ingredient being black. The felspar, which is rather light-coloured, looks a good deal like that of No. 328. The rock is coarse and not very compact, and on weathered surfaces has a singularly mottled appearance, caused by the black felspar being disseminated in somewhat prominent aggregations through the red felspar base. The rock is jointed, both horizontally and vertically, the vertical joints forming angles of 62° and 70° with the horizontal ones. In constitution, this rock is a syenite, but is almost certainly a metamorphosed rock. The minerals which compose it seem to be in irregular

lumps; and it is probably analogous in its formation to the basaltic grits, its relations being with the Anorthite and Palisade rocks, and its date cotemporaneous with the eruption of that rock.

623. Bears, apparently, E. of N. This rock is very ferruginous, very crystalline in its aspect, and exhibits decided polarity. In its structure it has a somewhat schistose appearance, especially on exposed surfaces, and is most likely an overflow from a N. 30° E. dike of basalt. Colour, blackish gray, with a shining appearance. It is the same as No. 613, which resembles "Nepheline rock," and which bears E. and W. The difference in bearing is easily accounted for, if it is a bedded rock, as it seems to be. Between the regular layers it is coated with oxide of iron, which gives that portion of the rock a thoroughly rusty appearance. It contains a great quantity of iron, and it is probable that it is from rock of this character that the ferruginous beds associated with the conglomerates have been derived. (See No. 603.)

624. Bears N. 45° W. Colour, purplish gray; fine granular; jointed. Composed of red felspar and black hornblende or augite. Resembles No. 618, but has more of a bluish tint. Magnetic. Smooth, conchoidal fracture. Bears most analogy to the N. and S. dikes. Weathered surfaces, black and smooth. Joints slightly incrusted with a zoolitic mineral, probably Heulandite. It is very compact, and shows no appearance of crystallization. Traverses No. 603 and No. 625.

625. Bears N. 30° E. Resembles No. 603, and is probably a dolerite. Colour, dark greenish gray. Minutely crystalline, with occasional larger crystals of a greenish felspar (?) disseminated through it. Irregular fracture. Is more nearly like No. 615. Weathered surface black, somewhat irregular, but tolerably smooth. The joints contain thin incrustations of carbonate of lime. Magnetic. Minute scales of mica disseminated through it. Is traversed by No. 624. It may be compared with No. 613, but is less crystalline than this last-named rock. Belongs to the basaltic series; contains a great deal of deep olive-green mineral, soft, and having a lighter green streak.

626. This specimen, which is from the bed of conglomerate which lies between the Palisade rock and No. 624, is a baked clay. It is of a rather light brick-red colour, shows traces of lines of deposition, and is somewhat amygdaloidal, the cells being very irregular in form, and compressed, with minute crystals of minerals, probably zeolitic, incrusting their sides. Has been much broken up and contorted by the intrusion of No. 624. Belongs to the lower shale-beds of the creek behind the Palisades. In some places the clay is discoloured, being dirty white or yellow, and in such instances is harder than the other parts of the rock.

627. Metamorphosed slate, from the same breccia as No. 626. Very fine-grained. Colour, bluish gray—not unlike the altered slate at the Lower Falls of Pigeon River. (See Nos. 4 and 8.) In the joints of these fragments are incrustations of a green mineral, supposed to be epidote. The slate is amygdaloidal, the cavities being filled with calcareous spar, surrounded, in many cases, by a ring of chalcedony. Fracture irregular and jagged, and, in some directions, splintery. A ring of zeolite, in some of the cells, surrounding a nucleus of calcareous spar.

628. Brecciated conglomerate—some of the fragments large, and of a deeper red

colour than the remainder of the rock. Most of the pebbles are amygdaloidal, with the cells very much compressed, and filled with minerals. The cells in each pebble have their long diameters parallel, but as they stand embedded, there is no uniformity between the direction of the cells of the different pebbles. The paste, which is of an earthy character, is also very full of amygdules, compressed, and having a uniformity of direction through the whole mass. In general appearance, this specimen resembles the ordinary red shale conglomerates, and may be compared with No. 201, and also Nos. 212, 259, 245, and 377. The elongated cells in some of the enclosed pebbles are very much bent and contorted. Shows two periods of action.

629. Bears E. and W. Very ferruginous; colour, reddish gray, with a slight greenish tint in some places. In the mass, fine granular; in parts, crystalline; the more crystalline portions seeming to be near joints, and to be of but little depth. The joints on weathered surfaces are very red. It is the rock described in 1848 as "Columnar Rock." It is disposed to become globular in the mass, the diameter of the globes being, occasionally, over twenty feet. In general structure, resembles some of the N. 30° E. dikes; and also bears some analogy to the volcanic grits, such as are found in the neighbourhood of Kawimbash, Inaonani, and Two Island Rivers. It is at some places an overlying rock, and is connected with the ferruginous grit-beds. At some localities it appears to bear nearly N. and S.; then N. 30° E., and again E. and W. The difference in bearing I consider to be due to the different directions in which the overlying beds are cut through and exposed. Very feebly magnetic. The crystalline portion is made up of deep-red felspar, white felspar, black hornblende, and peroxide of iron in lumps. A few quartz crystals are probably present, but it is not certain that the light-coloured mineral is not felspar. (See No. 633.) The joints are lined with zeolites, either apopholite or stilbite, and Heulandite (?). It has a tolerably straight fracture, though the surface is rather uneven, and shows a tendency to be nodular. At Two Island River, and below, this rock bears N. 30° E.

630. Bears N. 30° E. Colour, greenish gray, with a reddish tint. Disintegrates easily. Has an irregular, lumpy fracture. Heavy. So filled with green mineral, that it is difficult to determine its composition. Structure, granular. The green mineral which is so extensively disseminated through it is, probably, a variety of talc. B. B. in the forceps loses its green colour, and becomes whitish, and with difficulty becomes rounded on the edges, with slight intumescence. With borax, fuses to a clear glass, which, when cold, has a green tint, but is honey-yellow in the outer flame;—with salt of phosphorus, fuses to a white glass, with a silica skeleton. This mineral has, probably, been mistaken for epidote, as well as for chlorite. It resembles some varieties of the first in its fine granular and scaly disseminated state, and the latter in large lumps. It is the mineral so extensively developed in the volcanic grits, and which also occurs in thin veins in those rocks, associated with calcareous spar and zeolites, as well as in the metamorphosed shales at some localities. This rock is columnar, and overlying at many points on the Lake shore; and the dike to which it belongs has, probably, been one of the sources from which the volcanic grits of Two Island River and the neighbourhood were derived. It does not affect

the needle, although it appears to contain a large percentage of iron. Compares with No. 188, and similar rocks; also with No. 603 and No. 606. Weathers with an irregular, nodular surface.

631. I consider this rock to belong to the metamorphosed shale-beds of Nos. 110 and 139. It is exactly of the same structure and composition as No. 139. Colour, brownish red, purplish red; very compact; fine, granular. Fracture, rather smooth, and disposed to be conchoidal. Has small segregations of green mineral, like that of No. 630. The fracture is dull; the joints incrusted with thin scales of zeolites. Belongs to the "Hat Point" series. Is very easily scratched with a knife, and shows no traces of a crystalline structure.

632. Bears N. E. and S. W. This rock, which is related to Nos. 629 and 630, is semi-crystalline in structure, but appears to be a fine trap breccia; and was probably derived from the rocks just named. Colour, reddish gray, with numerous green points. In the great development of zeolites in lumps and small cavities, it bears no little resemblance to the altered shales of Shale Bay, where they are in near contact with an east and west dike. It has a very irregular, rough fracture; and seems to be composed, principally, of fragmentary crystals of zeolite, green earth, hornblende (?), and felspar (?), with a considerable percentage of iron. These minerals are not regularly disseminated, but occur in lumpy segregations. Numerous irregular, ragged cavities in some parts, lined with zeolites and green mineral. The red mineral is stilbite.

633. Bears E. and W. This is the same, in all respects, as No. 629. It is jointed, and forms very regular three, four, and five-sided columns. Many of its joints are covered with a thin scale of iron-rust. At a glance, it looks somewhat like the N. 5° E. dikes of some localities, but a careful examination shows very material differences in its structure. Colour, reddish gray, with spots and stripes of red. Coarse granular. Weathers with a tolerably even surface of a light gray colour. Magnetic. In general aspect, like No. 590, but not crystalline. (See No. 629.) In some places, shows alternate stripes of red and dark-coloured grains, the dark-coloured stripes being nearest the partings and joints, while the interior is red, with spots of green or olive-coloured soft mineral disseminated through it. This rock is spread over underlying beds at some places, and then the columns are perpendicular, or form an angle with the horizon equal to the angle of dip. In structure and material, may be compared with some volcanic grits.

634. Bears E. 30° N. Colour, dark gray; fracture, irregular, and disposed to be lumpy. Weathers with a smooth, light gray surface. Has a crystalline appearance. May be compared with No. 633, except with regard to colour (this rock being free from the red rusty grains and bands of No. 633), and crystalline structure, the structure of the previous rock being granular rather than crystalline. This rock traverses No. 635, and may, possibly, be the dike from which No. 633, at Bitobig Point, was derived; the trap at that place probably resting on No. 635. This, however, is not certain. It must be included among the basaltic traps, more especially as it seems to contain a mineral believed to be chrysolite. Weathers easily; and on exposed surfaces, falls to small pea-like fragments, when struck with the hammer. These fragments are dark gray internally, and greenish black externally.

635. Metamorphosed siliceo-argillaceous shales—colour, brick red. Fine granular; laminated; structure, compact. Fracture, generally smooth and even, and disposed in some of the beds to be conchoidal. In other beds, the fracture is somewhat rough, and shows numerous segregations, darker and apparently harder than the body of the rock. These beds belong to the same shales as Nos. 596, 599, 619, and 621. All these last, however, are metamorphosed in a higher degree than this rock.

636. Bears E. 10° N. Very fine granular; homogeneous. Colour, gray; with a few minute points of the soft olive-green mineral. Fracture, conchoidal, smooth. Joints and weathered surfaces black and brownish black. This rock is analogous in structure to Nos. 612, 618, and 624. It differs from No. 645 in being somewhat less crystalline in appearance, and in being of a lighter gray colour. It may be set down as a very fine-grained greenstone. Magnetic.

637. Bears E. 10° N. This rock is the same as Nos. 629 and 633. At the point of the bay where this specimen was taken, it is intercalated with a breccia and soft material containing much zeolitic mineral. It may also be compared with No. 632. From the association of this rock with beds of breccia at this place, I am inclined to class it with No. 188, which belongs to the volcanic grits. The different bearing it has at different points, is also evidence in favour of the opinion that it is a volcanic sedimentary rock, deposited during the basaltic period, and subsequently altered by intrusive dikes of trap. Its close association with the metamorphosed shale-beds also gives weight to this opinion, as similar bedded rocks at other points on the Lake shore, and in the interior, are associated with the shaly and conglomerate beds, and with the breccias. See Nos. 629 and 633 for descriptions of this rock. Does not disturb the needle.

638. Bears N. 45° E. This rock may, in one sense, be called a porphyry, as it contains numerous crystals of felspar and hornblende, embedded in a paste. The paste is granular, and made up of rounded grains, while the crystals of the two minerals named are fragmentary. Colour, brownish red; has an exceedingly rough, scabby-like fracture, looking like that of some of the baked clays; cross fractures without any definite direction, and jagged. The rock is irregularly laminated, and, when struck with the hammer, separates into very uneven plates of irregular thickness, the surface being unequal and lumpy. The body of the rock is fine-grained. It belongs to the shale-beds, and may be compared with Nos. 54, 75, 100, 107, 110, 140, and other specimens of the shale-beds from various localities. In general structure, it resembles most nearly Nos. 107 and 140. Magnetic. Weathered surface, irregular, but smooth, of a lighter red than the interior of the rock, and relieves beautifully the white crystals of felspar which are disseminated through it. This rock is traversed by at least two systems of dikes, and, probably, three.

639. Bears N. 10° E. Structure, somewhat granular, with numerous minute crystalline points. Colour, very dark purplish gray, with numerous dark, olive-green spots made by the magnesian mineral. In general appearance, it much resembles the metamorphosed shales referred to when speaking of No. 638. It is, however, more crystalline in its structure, and is, probably, a trap. It is compact, and weathers with a tolerably even blackish surface.

640. Bears N. 45° E. (?) This rock may be compared with No. 589, which it resembles in all respects. It is crystalline; of a greenish-gray colour; weathers with a darker surface than No. 589. It belongs to the greenstones. Magnetic. Crosses No. 638.

641. Bears E. and W. Very fine granular; homogeneous; colour, greenish gray; very compact; prismatic; even, smooth fracture; no appearance of crystallization. Weathers with a smooth surface, of a lighter greenish gray than a fresh fracture. In the joints, dark-coloured, nearly black; some of the joints lined with a thin film of a mineral, greasy to the touch, and soft, probably chlorite; this film looks as though it were varnished. Belongs to the basalts; or, it might, perhaps, be called a basaltic greenstone. Magnetic.

642. Bears N. and S. Colour, dark greenish gray, with stains of red oxide of iron; weathered surface, black. Compact. Crystalline. Magnetic. Resembles in appearance and composition No. 634. Is like No. 633, in the red stripes in the partings and joints. Belongs to the basaltic traps, and may be put among the dolerites; though it is more coarsely crystalline than specimens of that rock from Heinheim, in Germany. Traverses No. 643 and No. 644.

643. Bears E. and W. Colour, dark gray, with a purplish tint. Structure, rather granular; with large tabular crystals of green felspar embedded. Bears a general resemblance to No. 636. Jointed; some of the joints stained of an ochreous colour; others blackish, or brown with a bluish tint. Fracture even, and disposed to be conchoidal. Breaks into prismatic fragments, some thin. May be called a basaltiform porphyry. Traversed by No. 642. Traverses No. 644.

644. Bears N. 20° E. Resembles the "Basaltite" or (Cornean) "Compact Metaphyre," of European geologists, found near Gottesberg, in Germany. Very compact; fine-grained; homogeneous. Colour, dark gray. No crystalline points. In some respects very like the metamorphosed shales. Joints covered with a bright red, ochreous coating. Weathers with a smooth surface.

645. Bears E. and W. Colour, dark gray. Crystalline; very fine-grained. Very compact. Fracture, smooth; conchoidal. Weathers with a smooth, black surface. Prismatic. May be compared with Nos. 592, 600, and 601, all of which appear to be the same. This rock and No. 601 are alike in all respects. Magnetic.

646. Bears E. 15° N. Greenstone. Somewhat coarsely crystalline. Composed of black hornblende, green and white felspar, and a green mineral, supposed to be serpentine. Prismatic. Jointed; the joints stained with iron-rust. Fracture indefinite, and very irregular in some specimens; in others, prismatic. Weathers with a thick coat of a rusty colour, which scales off, when struck with the hammer. Magnetic. May be compared with No. 594, from which it differs but little, or not at all.

647. Bears N. and S. (?) Greenstone. Colour, gray. Composed of hornblende and felspar—the latter mineral mostly white, with some greenish crystals. It is, probably, Anorthite. This rock is rather coarsely crystalline, with an uneven, irregular fracture. Weathered surfaces, black. It differs from No. 646, in being much more coarsely crystalline, and much lighter-coloured. Magnetic.

648. Quartzose sandstone—thinly laminated in some of the beds, and in some rather

shaly. Prevailing colour, gray; some beds, light gray. Composed of grains, both rounded and angular; very firmly united by an argillaceous cement. Some of the beds rather more compact than others. Some of the finer-grained, greenish-gray beds contain large rounded pebbles of argillaceous shale, embedded. May be compared with No. 418, though it contains less hornblende and felspar, and more quartz, than the Fond du Lac rock. It may also be compared with No. 451, St. Louis River, and No. 110. Not magnetic. Fracture, even and granular. Weathered surfaces somewhat uneven, and darker than the body of the rock. Joints of the dark-coloured and finer-grained varieties incrusted with a flesh-coloured mineral, probably felspar.

649. Bears N. 10° E. Very fine-grained sandstone—like that brought from Gersdorf, in Saxony. Colour, gray; minutely crystalline. Fracture, smooth; conchoidal. Jointed. Weathered surface black; scales off in thin crusts. Not magnetic. Very compact.

650. Bears E. and W. Basaltic (?). Resembles No. 644. Very compact; fine-grained; homogeneous. Easily marked with the knife. Much like some of the metamorphosed fine-grained argillaceous slates. Numerous joints; difficult to get a fresh fracture. It may be compared with No. 588. Colour, gray, with a light bluish or purplish tint. Fracture, smooth and conchoidal. Joints, somewhat rusty. Weathers with a black surface; discoloured for the depth of one or two lines, the discoloration being of a yellowish-gray colour. Not magnetic.

651. Bears E. and W. (nearly). Basaltic. Colour, very dark greenish gray, with a faint purplish tint. Very irregular, nodular fracture, in which it resembles Nos. 630 and 632. Amygdaloidal—the cells being filled, principally, with thalite, the dark olive-green magnesian mineral, which is also distributed liberally, in grains, through the body of the rock. Weathers with a dirty yellowish and greenish-gray surface; iron-shot, but which does not fall off in scales. No. 115 is from the same locality. The body of the rock is nearly homogeneous, and shows no appearance of crystallization. It resembles most nearly the basaltite of Gottesberg, in Schlesien; and bears a great analogy to the dolerite of Steinheim. This dike, if continued westward, would strike Two Island River, about fifteen miles above its mouth. On that river, and south of the point where it would intersect the dike, is the great development of No. 188, which rock, together with the succeeding rocks, up to No. 193, inclusive, were probably derived from this or a similar dike. If the Two Island dike begins nearer the Lake, as it probably does, then the dike, if the same, bends to the N. and E., forming a southeasterly curve. The specimens brought from Two Island River, and which have been set down as volcanic grits, contain the same mineral (thalite) found in such abundance in the rock under consideration. They are, however, more granular and coarse in their structure, and contain a very large percentage of iron, giving them a deep red colour, but have the same nodular fracture.

652. Volcanic grit, at the mouth of Two Island River. (See No. 190.) This rock was probably derived from No. 651. Contains the same mineral developed in No. 651, and also in No. 190, of Two Island River.

653. Greenstone. Bears N. and S. Runs under the Great Palisade. This is a

heavy dike, and, in all respects, is like that on the easterly side of Pigeon Bay, and marked No. 647. The weathered surface, however, is greenish gray, of a lighter colour than the fresh fracture. Both these rocks, probably, contain diallage.

654. Greenstone—colour, dark gray, nearly black; the hornblende crystalline, the felspar white.

655. Syenite—composed of fine crystalline grains of hornblende and red felspar; but little quartz; contains iron pyrites.

656. Metamorphosed clay slate, in contact with a dike—colour, dark gray; contains a few scales of mica; the planes of stratification and cleavage nearly obliterated; stained with oxide of iron.

657. Argillaceous slate—very thinly laminated; colour, nearly black.

658. Siliceous shale—in thin laminæ; colour, dark reddish black; somewhat metamorphosed.

659. Very fine-grained basaltic-looking rock; somewhat schistose; probably a metamorphosed rock.

660. Greenstone—colour, dark greenish; very fine-grained; compact.

661. Similar to No. 660, but with well-developed minute crystalline grains of hornblende.

662. Hornblende rock—coarsely crystalline; dark-coloured, the quartz being of a dirty greenish colour; graduates into syenite; the felspar predominating, and sometimes in large crystals.

663. Like No. 661, but rather more crystalline; fine-grained; contains some iron pyrites.

664. Greenstone—colour, gray; fine-grained; compact; even fracture; contains small grains of reddish felspar.

665, 666. Very fine-grained basaltic-looking rock—colour, greenish gray. May be called a greenstone.

667. Syenite—flesh-coloured felspar predominating; porphyritic. A beautiful rock in the mass.

668. Syenite—contains but little quartz or hornblende, being made up principally of red felspar; passes gradually into regular greenstone.

669. Quartzite—fine granular; colour, gray. A metamorphosed sandstone.

670. Metamorphosed siliceous shale—very fine-grained; colour, dark purplish; very compact; fracture conchoidal; somewhat impregnated with oxide of iron.

671. Quartzite—colour, reddish gray; fine-grained; in some places resembles syenite. A metamorphosed sandstone.

672. Quartzite—colour, gray; fine-grained; sub-crystalline. A metamorphosed sandstone.

673. Greenstone—crystalline; compact; irregular fracture; colour, dark greenish.

674. Slaty greenstone—alternating with siliceous schist; colour, gray; contains grains of red felspar.

675. Greenstone—highly and minutely crystalline; porphyritic; colour, from light to dark gray.

676. Quartzite—fine-grained; compact; colour, dark gray. A metamorphosed sandstone.

677. Metamorphosed argillaceous slate, with intercalations of basaltic rock.

678. Altered argillaceous slate—colour, grayish black; joints and seams coated with carbonate of lime.

679. Greenstone (?)—a close-grained, compact rock; slightly crystalline in structure.

680. Metamorphosed marly clay—colour, red; very compact; has a trappous appearance.

CHAPTER III.

SECTION I.

NARRATIVE OF THE EXPLORATIONS MADE IN 1847, BETWEEN LA POINTE AND ST. LOUIS RIVER; AND BETWEEN FOND DU LAC AND THE FALLS OF ST. ANTHONY; AND ON THE ST. CROIX RIVER.

In accordance with the instructions received from you at La Pointe, on the 5th of July, I remained at Madeline Island, after your departure for Stillwater, until the 26th of that month, for the purpose of making a series of barometrical observations, to be used in referring the various observations throughout the District to the elevation of Lake Superior above the Gulf of Mexico, as a standard of comparison.

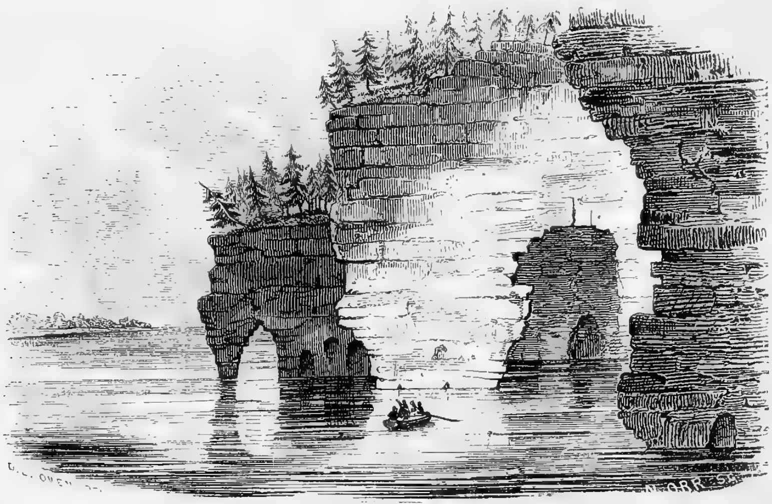
Previous to leaving La Pointe, I made arrangements with Mr. Jeremiah Hughes of that place, whose acquirements and zeal for scientific investigation well qualified him for the task, to institute, in connexion with a meteorological register, a series of observations on the so-called "tides" of Lake Superior (the periodical or accidental changes in the level of the lake), phenomena so frequently observed, but the cause of which is veiled in so much obscurity.

He began the observations, and pursued them with diligence for several months, but, unfortunately for the interests of science, died before he had carried his investigations sufficiently far to admit of generalization.

Through the kindness of Mr. Rice, of the Fur Company, I took passage, on the 26th of July, in his boat for Fond du Lac, or, rather, for the Trading-Post of the American Fur Company on the St. Louis River. During the passage, I availed myself of every opportunity for making observations on the Lake shore; thus adding to the barometrical series begun at Madeline Island.

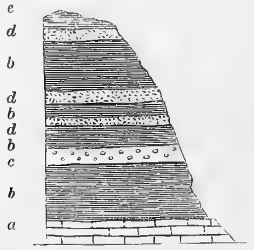
Between Madeline Island and Bark Point, red sandstone shows itself on the Lake shore for nearly the whole distance. At Pointe Detour, and many other places, the bluffs are perpendicular, and from twenty to forty feet in height; and are overlaid by beds of sand, drift, red marl, and clay. Beyond the mouth of the small river opposite Oak Island, the rock has been worn, by the incessant action of the waves, into most singular and interesting architectural forms. Among these, the pillar and arch predominate. These *Pillared Rocks* extend for many miles, and are inte-

resting, not only on account of their picturesque appearance, but also as illustrating the means by which the Lake is gradually enlarging its southern boundary. Some of the arches are circular, but most of them are pointed. In the space of two hundred yards, at one point, I counted over fifty arches, all possessing great regularity, and resting upon pillars almost as symmetrical as though they had been subjected to the chisel of the artisan. Through these arches, the waters of the Lake dash with every swell, and their unceasing play has hollowed out numerous deep caverns. Two caves were particularly noticed, supported at intervals by pillars of all sizes, from twelve feet to half the number of inches, in diameter, and forcibly reminding one of the descriptions of the celebrated cave of Elephanta. Regular architraves, friezes, and cornices are constantly seen, but it is only occasionally that a pillar shows a base, as they are sunk beneath the waters of the Lake. Some of the arches are



RED SANDSTONE; SOUTH SHORE OF LAKE SUPERIOR.

large enough to permit the passage of a Mackinaw boat. There is generally from twenty to forty feet of sandstone resting on the arches, the layers being nearly horizontal, and supporting a capping of majestic forest trees, giving to the whole scene an exceedingly grand and picturesque appearance.



c. Indurated clay, overlaid by soil.

d, d, d. Gravel beds, with some large pebbles.

c. A bed containing boulders.

b, b, b, b. Red and yellow sands.

a. Red sandstone.

Beyond Bark Point, the shore is bound by hills of red clay and marl, with occasional exposures of red sandstone at various heights. In the vicinity of Rush River, the banks of sand and red clay are high, with seams of gravel and small boulders running through them horizontally, near their summits, while numerous boulders of

crystalline rocks are embedded in the upper stratum. This is the character of the shore to the mouth of Bois Brulé River. The preceding section of a bluff, about half a mile above Cranberry Bay, will convey a correct idea of the disposition of the more recent deposits overlying the sandstone.

The prevailing colour of the sandstone on the south shore is red, but at many points the lower beds are drab-coloured; and there are frequent alternations of red, white, and drab-coloured layers. Some of the beds resemble the sandstones of the Chippewa, St. Croix, and Kettle Rivers. Many of the beds in this whole region are pebbly, and frequently contain such numbers of large pebbles as to give them the character of a conglomerate. The lower stratum in the vicinity of the above section is of considerable thickness, and in the upper part contains numerous large, round, smooth pebbles, and among them many of a reddish-coloured quartzose porphyry, from two to three inches in diameter. Above this are thin strata of shaly sandstone, generally very coarse-grained, and even pebbly, with numerous white stripes and spots. Sometimes thin seams of slightly coherent pebbles, small and rounded, are interposed between the beds. In general, these rocks are very loosely cemented, and when exposed to the weather, soon disintegrate.

The following section occurs about three hundred yards above the mouth of Cranberry River, and is given here for future reference, when the metamorphosed beds north of the Lake come to be considered.

	Feet.	Inches.
1. The lowest stratum is exposed seven feet above the present level of the Lake, and is composed of a rather coarse-grained red sand, with buff-coloured stripes traversing it, from one to three inches thick. The upper part is banded by red and white stripes, from one-fourth to half an inch in thickness, marking lines of deposition, which dip about 12° to the reverse of the general dip of the rock; while other lines, above these, dip in the same direction at an angle of 45°. (The general dip of the rocks in this section is southeast from 3° to 4°), . .	7	
2. Red sandstone, rather more compact, but soft, coarse, and easily affected by the weather, ...	3	
3. A very coarse, dark red, sandy shale, extremely soft and decomposable,	4	8
4. Sandstone—yellowish red in the lower part, red in the upper, compact in some places, but soft and shaly-like in others, . . .	5	
5. Alternations of compact and shaly layers, ...	4	5
6. Sandstone—partly compact and partly shaly, showing numerous cross lines of deposition; weathers easily; full of small, irregular, roundish spots of a yellow colour; much broken by joints. The upper surface of this bed contains large pebbles of rounded quartz and trap rocks, .	5	4
7. Red sandstone—rather compact; overhangs the lower beds in the escarpments; the edges are sharper, and the angles better defined, .	3	
8. Red clay, ...	16	
9. Sandy marl, ...	10	

The marl-beds increase in thickness as you recede from the shore. In a small ravine, about three hundred yards distant from the Lake, the clay and marl-beds measured fifty-eight feet.

Few of the beds exposed in the escarpments along the shore can be traced for

any great distance, without greatly increasing or diminishing in thickness. They often thin out in the distance of a few yards, and a stratum of considerable thickness at one point, will frequently allow the beds above it and below it to come together at others, giving to them the appearance of "dove-tailing." The irregular stratification and frequent cross lines of deposition, together with the ripple-marked surfaces of the beds, go to show that they were deposited at no very great depth below the surface of the waters, and were constantly subjected to the modifying influences of currents, tides, and other disturbing causes. Some of the beds appear to have been deposited on an irregular rolling bottom.

The Lake shore, for the entire distance between the mouth of the Bois Brulé and the "Entry," is a clay bank, varying in height from six to forty feet, and without any exposure of the red sandstone; which is met with, however, on all the small streams that come into the Lake between those two points, and maintains, throughout, the general dip to the southeast, at a small angle; never exceeding 4° at any point noticed by me, except in the immediate vicinity of trap dikes, and then only for short distances.

Nine miles beyond the mouth of the Bois Brulé, Poplar River comes in. About eight miles from its mouth, it is crossed by a trap dike, bearing nearly east and west, and, a few miles further south, another broken trap range crosses it. Owing to the numerous rapids on it, Poplar River is not navigable for canoes. Nine miles east of the "Entry," or mouth of the St. Louis River, Spawn River enters the Lake. On this river a vein of copper ore has been discovered by Mr. C. H. Oakes, of La Pointe. It is, however, below low water mark.

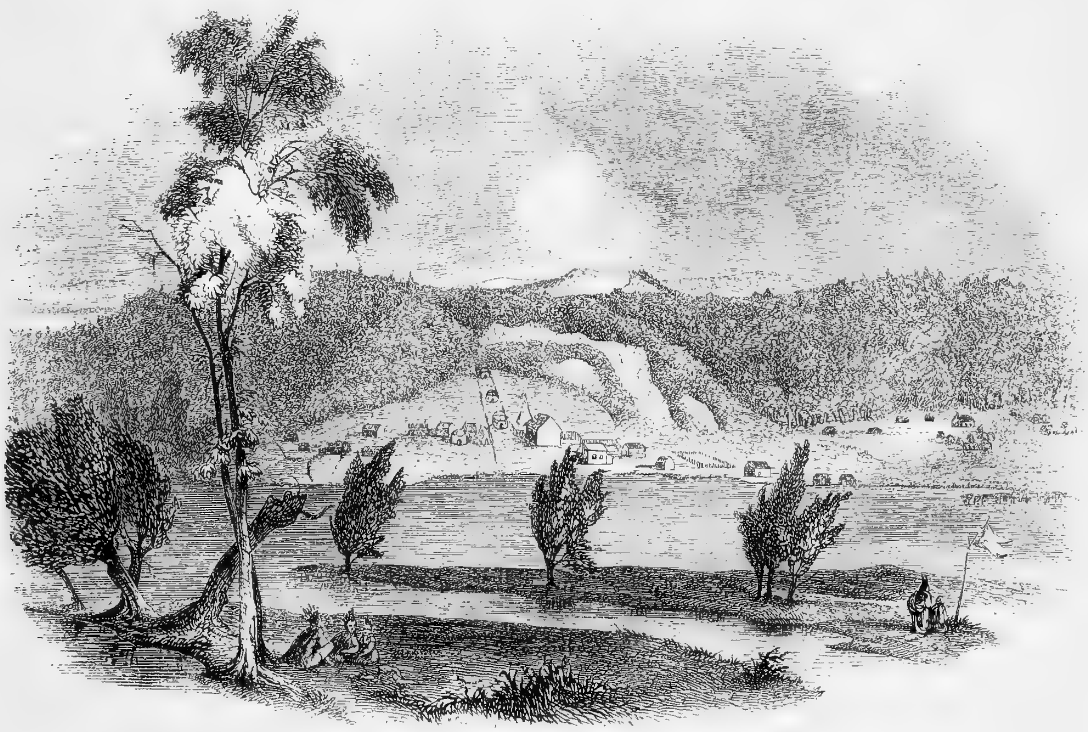
The mouth of St. Louis River is narrow, with a sufficient depth of water, however, to admit boats of large size to pass the bar at all times.* It lies between two narrow strips of land, which run from the highlands on either side to the "Entry," and divide the waters of the Lake from a small bay formed by the widening of the river. On the north shore, the hills are from four to five hundred feet in height, and approach very nearly to the Lake. On the south side, they are distant several miles, and not over two hundred and fifty feet high. On the south side of the small lake within the "Entry," Left-hand River comes in. On one of its tributaries copper ores have been discovered in considerable quantities, and several locations have been made, which will be described in the notice of the geology of Black River.

From the "Entry" to the Fur Company's Post, a distance of eighteen miles, St. Louis River is wide, and of sufficient depth to admit the passage of the craft which ply upon Lake Superior. It runs through a rich alluvial bottom, from one to three miles in width, which is partly timbered and partly covered with natural meadows. It is somewhat crooked, with reaches from a quarter of a mile to a mile in length, and contains numerous islands, some wooded and others covered with excellent grass. The banks on either side, as well as the islands, are composed of clays and

* In 1850, the propeller Manhattan, Captain Caldwell, entered this river without difficulty, and proceeded as far up as Fond du Lac Village. The river at the time was not above its ordinary stage, and at the lowest part sounded there was over six feet water in the channel. This brings the steam navigation on Lake Superior within thirty-five miles of the Mississippi at the mouth of Sandy Lake River.

siliceous marl. Although the numerous islands and bars tend to complicate the navigation somewhat, for larger vessels, yet the rushes which spring up at every spot where the water is sufficiently shallow, form obvious marks for the guidance of a pilot unacquainted with the channel.

The trading-house of the Fur Company is situated on the north shore of the river, and immediately opposite is the corner, not only of the Chippewa Land District, but also of the State of Wisconsin. It is also the corner of the boundary lines, running south and east, between the lands ceded to the General Government by the Chippewas, in 1842, and those still held by that tribe east of the Mississippi.



FOND DU LAC VILLAGE, ST. LOUIS RIVER.

The village, represented in this cut, from a sketch by Major Owen, is well situated, in Minnesota, on a rich alluvial bottom, which contains sufficient area for the site of a large city; and will become a place of great importance when steam navigation comes to be extended up the Northern Mississippi as far as Sandy Lake, which will undoubtedly be done as soon as the Indian title to that portion of country is extinguished.

Opposite the village, on the south bank, in Wisconsin, and for some distance below, three ancient lake terraces show themselves, rising in succession from the present level of the river banks. The highest one, which is best defined on the Minnesota side, immediately behind the village, is one hundred and twenty-five feet high; the lowest one, on the south side, on which Landry's house stands, is about fifteen feet above the present banks; and the next terrace above, which is the middle one, rises to the height of twenty feet.

There is every indication that the waters of the Lake basin once had their

western terminus above this place; the barrier being at the junction of the metamorphic and sandstone series, several miles up the river; and following the line of bluffs about a mile and a half south of Landry's house, in a southeasterly direction, crossed below the Falls of Black River, and continued along the base of the trap ridges to the present Lake shore, at some point far to the east. This would include a great portion of the Left-hand River country, as well as a portion of the Aminekan and Poplar River lands.

At the time I visited this place, the chiefs of the Chippewa Indians, from all parts of the territory, were assembled for the purpose of hearing proposals for the purchase of their unceded lands east of the Mississippi. In consequence of the country through which I had to pass being almost totally unknown, except to the Indians, I availed myself of the opportunity offered by so great an assemblage, to acquire from them as much geographical knowledge as possible.

In order to obtain a general idea of the geological structure of the region upon which I was about to enter, as well as of the bearing of the great ranges which traverse it, it became necessary for me to leave the District, and proceed a short distance into the Indian country. Accordingly, with two Indians for guides and voyageurs, I ascended the St. Louis River as far as the Upper Falls, partly by water and partly across the country. After making the desired observations, I returned to the Trading-House, following the bed of the river the whole distance, and was thus enabled to procure measurements at every desirable point between the Upper Falls and Lake Superior. A number of observations, made at the Fur Company's establishment, also afforded me a mean by which to test the probable accuracy of those to be made between that point and the Mississippi River, and referred to the level of Lake Superior as a base.

After remaining six days on St. Louis River, I started on foot, with two half-breeds, Joe Cadotte and Pierre Le Meur, for packmen, to cross the country lying between St. Louis River and the head of Lake St. Croix. Neither of these men had ever been in that section, or knew anything of the route, and our sole reliance was on the Indian map and my compass to lead us to our destination. From the best information which could be obtained, it was expected that the journey would not occupy more than five days, allowing ample time for making all the observations necessary in such a reconnoissance. In addition, therefore, to the specimens collected on St. Louis River, and the necessary camp equipage, provisions for that length of time were added to the packs;* and on the morning of the 5th of August we crossed the river and started on our journey.

Nearly two miles south of the river, we ascended the high range of hills which bear off towards the south shore of Lake Superior, and entered on what we supposed to be the trail to Lake Pokegoma. Owing to the heavy rains which had recently fallen, the swamps were rendered almost impassable; this, together with the weight of the packs, made our progress necessarily slow.

The bluffs south of the Trading-Post are composed of red sandstone, which crosses

* I must here acknowledge the many favours received of Mr. H. M. Rice, who, on this occasion, furnished me with all the provisions for my journey. I am also indebted to General Verplanck for various kindnesses.

St. Louis River between the Lower Rapids and the Post, with a dip to the southeast, and is continued eastward to the boundary line of the District. The thickness of the sandstone at the bluff is two hundred and sixty-nine feet. It is overlaid, as on the north side of the river, by sand and marl-beds.

As no rocks were seen in place between the hills near St. Louis River and Kettle River, and the general features of the water-shed passed over have been noticed in the first Chapter of this Report, I shall not give a detail of my observations along the route, but only allude to some of the incidents which delayed my arrival at Stillwater, and mention some special characteristics of the country.

On the morning of the 7th, one of my men was attacked with fever, and was unable to travel, from that time, more than from five to ten miles a day. And, to add to the difficulty, the trail disappeared that day and no trace of it could be discovered. The route from St. Louis River to Pokegoma has been used principally for winter travel; few even of the Indians passing it at any other season. It runs directly across swamps and lakes, which are impassable, except when bridged by ice; while in the most favourable situations, the path is easily obscured by vegetation, and, if disused, soon becomes entirely obliterated.

About fifteen miles south of the St. Louis River, quite a number of first-rate pines were observed, and, from the indications, it is probable that they extend over a considerable extent of country. The value of the timber here will depend entirely upon the facilities which may hereafter be provided for transporting the lumber to the Lake, or to some of the tributaries of the St. Croix capable of floating logs. The ridges and higher lands in this neighbourhood are covered with an excellent growth of sugar maple, with white birch, ash, and linden.

About twenty-five miles, as nearly as I could judge, south of Fond du Lac, our trail crossed a high, rolling section of country. A good deal of it is prairie, covered with whortleberry bushes and strawberry vines; while, in the low grounds, hazel abounds. On parts of the route, the ground is literally covered with boulders, mostly of granitic rocks. Small pine, birch, and shrubby oak succeeded, with strips of sugar maple. This brought us to the top of the water-shed. From this point to Kettle River the country presents a succession of small lakes, swamps, meadows, and ridges, covered with birch and small pine.

We reached Kettle River on the evening of the 9th, entirely destitute of provisions, my men having imprudently given a portion of the small stock with which we started to an Indian met with on the way. My gun was now the only dependence for food.

Kettle River is about sixty yards wide at the point where we struck it, and is, apparently, deep enough to float a steamboat. It is full of boulders, however, and hardly navigable for canoes.

At this place the sandstone shows itself on the right bank of the river, twenty feet in thickness, and dipping to the southeast. The beds are thick, tolerably compact, and reddish-coloured; and overlay beds of a very fine-grained siliceous shale, which is exposed at the water-level on the left bank of the stream. According to information derived from an Indian, this point is six miles above the Falls of the river. The sandstone continues to show itself in the hills for several miles; and

then our way lay through swamps and wet meadows for some distance. About ten miles further on, a succession of maple ridges were passed, with a deep rich soil. This strip of land, however, is believed to be narrow.

Beyond these ridges the sandstone again comes to the surface, and shows itself, at intervals, for the space of several miles. It is covered, generally, by a soil equal to any in the Lake region.

About sixteen miles southwest of Kettle River, I passed through a fine pinery, which extends as far as Lake Pokegoma. A great portion of this pinery remains untouched; many fine trees, however, have been cut on the small tributaries of Snake River. Some of the valleys in this region are literally covered with boulders, while the ridges bear a dense growth of birch, linden, box-elder, and fir, with large pines.

At two o'clock, P. M., on the 12th, we reached Lake Pokegoma, having been seven days in traversing a country, which, I have been told, has been passed over by Indians in thirty-six hours' constant travel, when the lakes and swamps were frozen. Our route, so far, was an exceedingly winding one, having often been turned aside from our course by lakes and swamps, and compelled to walk many miles to avoid them.

When we reached Pokegoma, my sick packman was entirely exhausted, and he was left on the north shore of the lake, while I went on to the Indian village for the purpose of procuring a canoe to transport him across the lake. After considerable delay, the Indians all being drunk, a canoe was obtained, and we crossed the lake to a house belonging to Mr. Russell, who was formerly government farmer at this place. Mr. Russell's agent supplied me with pork, flour, and potatoes.

Next morning I procured a passage in a canoe about to descend Snake River for my sick man, and having hired a half-breed youth to carry a part of his pack to the mouth of Sunrise River, while I added the remainder to mine, at two o'clock, on the 13th, we entered on the trail to St. Croix River. The country between Pokegoma and the St. Croix, along this route, is an excellent one. The principal timber is sugar maple, poplar, oak, ash, walnut, elm, hornbeam, and some birch and pine. Between some of the low ridges wet meadows occur, but most of them are sufficiently dry, at the proper season, for mowing.

Four or five miles south of the crossing of Reed Creek, small prairies began to appear, interspersed with occasional wet meadows; the high intervening prairie lands supporting a thin growth of oak timber. About five miles before reaching the mouth of Sunrise River, the character of the country is entirely changed; and, from the nature of the soil and vegetation, I judge this to be on the northwestern boundary line of the country, described in Chapter I., as included in the second division.

At the mouth of Sunrise River I met Mr. A. Randall, a member of the Geological Corps, on his way to Lake Superior. He returned with me to the Falls of the St. Croix, from which point I hastened to meet you at Stillwater.

After receiving further instructions from you at Stillwater, I crossed the country to St. Paul, and thence by way of St. Peter and the Falls of St. Anthony, for the purpose of making barometrical observations. I returned to Stillwater on the 25th

of August, and on the morning of the 27th started on my return to Lake Superior, with the view of examining the eastern line of the District, from Lake Superior to its southern termination. In this reconnoissance I was accompanied by Mr. W. F. H. Gurley; and I take great pleasure in mentioning here his uniform gentlemanly deportment, and attention to the duties assigned him, while associated with me.

We proceeded by land to the Falls of the St. Croix. At that place we procured a canoe, and ascended the river to Upper St. Croix Lake. From thence we made a portage to the head of the Bois Brulé, and descended that river to its mouth. Here we were detained two days by high winds, and then proceeded to Madeline Island, where we arrived on the 11th of September.

During this journey I made a great number of barometrical observations, the result of which is laid down on the plate of the profile of the country.

I now subjoin a few observations on the geology of the St. Croix, in addition to those already made incidentally by yourself.

In ascending that stream, exposures of white and drab-coloured sandstone are met with between the mouths of Rush and Wood Rivers. These rocks are coarse, slightly cemented, and disintegrate easily. Some of the layers are waved and thinly laminated, while others show cross-lines of deposition. Two miles above the mouth of Wood River, there is an exposure of twenty-five feet of the same rock. At this place the lower beds are thinner and softer than the upper ones, which are tolerably compact, and variegated by horizontal stripes of a darker colour than the body of the rock.

Opposite the first island above the mouth of Snake River, on the east side, is an exposure of shales and sandstone, underlying about forty feet of drift. The rock is in thin beds, of a greenish-gray colour, and intercalated with seams of bluish and deep-red indurated clays. The clay-beds are from four to eight inches thick. A short distance further up stream, these beds are capped by thirty feet of sandstone, exposed in the hillside in a mural escarpment. Immediately above this, on an island, trap shows itself; and five hundred yards higher up, beds of yellowish sandstone, with a red bed underneath, occurs in the east bank of the river, tilted up at an angle of 45°, and dipping to the southeast. In the bluffs, just above this place, is an exposure of thirty feet of drab-coloured sandstone. Nearly opposite the mouth of Kettle River, on the east side of the east chute, is an exposure of red brecciated conglomerate, the fragments and pebbles being all of red sandstone. The dip of the rock here is somewhat doubtful, but it appears to be to the northwest.

Near the head of Kettle Rapids, on the main shore, a dark-red, fragmentary sandstone occurs, overlying a yellowish-coloured rock of the same kind, and showing every evidence of having been subjected to metamorphic influences. On an island in the Rapids, near by, is an exposure of No. 680, of considerable extent; and at the head of the Rapids is a heavy trap dike, bearing northeasterly and southwesterly. Above the Rapids, on the west side of the river, the course of the dike is marked by a low ridge of angular fragments, and, as it extends southwesterly, by a number of islands in the stream. The exposures of drift in this vicinity, measure from thirty to fifty feet in height.

About seven miles above the mouth of Nemakagon River, the St. Croix is obstructed for the distance of half a mile by ledges of red sandstone, which cross the stream, forming rapids. The rock is in thin beds, and dips southeast at an angle of 12°. It is rather coarse-grained in some of the beds, and has thin angular fragments of a very fine jasperoid rock embedded in it. It is principally made up of angular grains of quartz, with but few rounded ones. In some places it has the appearance of having been subjected to heat. The thicker beds are finer-grained and more compact, and resemble the altered sandstones of Black River.

Five miles above Pine Island, the river runs over beds of sandstone, dipping east of south, at an angle varying from 5° to 7°. One mile further up, the dip is to the southeast, and the rocks resemble, in all respects, the shaly sandstone beds of Lake Superior. These rocks, which are very fine-grained and fissile, are also associated with beds of red sandstone conglomerate.

Above Pine Rapids, for the distance of fourteen or fifteen miles, the river is a succession of rapids, only separated for short distances by broad, shallow basins of comparatively still water, with numerous boulders scattered through them. Nearly all the rapids above Nemakagon River are caused by accumulations of boulders, which generally cross the stream in lines corresponding with the line of bearing, and appear to have been arrested and formed into dams by the broken and uptilted edges of beds of the red sandstone. From numerous instances which fell under my observation, I am inclined to the opinion, that the disturbances accompanying the eruption of the trap dikes, which traverse this region in a southwesterly direction, produced numerous slight faults in the sedimentary rocks of that period, and thus gave origin to the many sandstone *dams* which are now found crossing the rivers, and producing rapids and basins in the way alluded to, and also to lakes of the "first variety," as described in Chapter I.

From a great number of observations, made not only on this but also on other rivers, I am led to the conclusion that this is the general cause to which may be attributed the formation of a majority of the rapids met with on the streams in this section of country, and extending as far as the Mississippi, where the result of its action is conclusively shown in the formation of the Falls of St. Anthony, which bear every evidence of having been caused by a fault; which fault was, in all probability, produced at the time of the eruption of the trap range which crosses the St. Croix River at the Falls, and pursues a southwesterly course in the direction of St. Anthony.

Along the portion of St. Croix River under consideration, the banks are low, and the bottom lands extend from one hundred and fifty to two hundred and fifty yards on either side, to the base of the drift hills, which rise from one hundred to one hundred and twenty feet in height, to the general level. The drift contains but few large boulders, but many small ones, of granite, syenite, hornblende, and other crystalline rocks, and numerous fragments of slate and red sandstone. Among them, I found a small copper boulder. The country on the upland is barren, bearing only clumps of small pine, a few bushes and stunted shrubs, coarse grass, and wintergreen.

A short distance above the point last designated, the shaly sandstone and its

associated conglomerate, have no perceptible dip. On the west side of the river is a ridge, varying from ten to twenty feet in height, and composed of conglomerate and disintegrating sandstone, the upper part resembling very much the red marls of the Lake region. The ridge extends about eighty yards back to a cedar swamp, which reaches to the drift bluffs, under which the conglomerate and sandstone disappear, as shown on this Section.

Fourteen miles above Pine Rapids, there is a large exposure of sandstone, forming rapids and islands in the river. It is in very thin layers, and dips southeast by south.

Above this place, and just below Lake Nemakweagon, the bed of the river, which is shallow and greatly expanded, is made by thin beds of red sandstone, traversed by numerous parallel cracks or fissures, having a northeast and southwest direction. The rock is very close-grained, and shows fine lines of deposition, some of which are light-coloured, and give to the rock a banded appearance.

At the upper end of Lake Nemakweagon the red sandstone, which has been traced from Snake River to this place, is exposed in low knolls and ridge-like prolongations through the woods, and approaching to within a hundred yards of the river bank.

Between Nemakweagon and Pijiki Lakes, there is a ridge, varying from fifty to seventy-five feet in height, bearing northeast and southwest, and on the northwest side of it, red clay-beds are to be seen. The nucleus of the ridge is probably red sandstone, but it is concealed by the drift deposits.

The general direction of the ridges which form the highlands about the sources of the St. Croix and Bois Brulé Rivers, is northeasterly and southwesterly, inclining more to the east and west than the ridges further south.

After passing the water-shed, the first rock found in place is No. 456 of the Descriptive Catalogue, which crosses the Bois Brulé, bearing east and west. At various points between this place and Lake Superior, beds of red sandstone, shale, and conglomerate, are exposed in the river banks, covered by heavy deposits of red clay, sandy marl, and drift. The sedimentary rocks dip gently to the southeast.

SECTION II.

NARRATIVE OF EXPLORATIONS MADE IN 1847, BETWEEN PORTAGE LAKE AND THE HEAD-WATERS OF WISCONSIN RIVER, AND DOWN THAT STREAM TO WINNEBAGO PORTAGE.

We remained at La Pointe five days; the time being devoted by the men to rest, and by ourselves in procuring supplies for our journey to the Mississippi.

On the 18th September, we left La Pointe for the head-waters of Wisconsin River,

carrying with us provisions to last us to Prairie du Chien; or, at least, until we could reach the first settlement, which, we were told, was at "Big Bull Falls." I camped that night at the mouth of Bad River, and next morning started, by way of Montreal River and the Portage Lake Trail, for the head-waters of Wisconsin River. This path, which is used by the Fur Company for the transportation of goods to their trading-posts in this section, is estimated at forty miles in length, and is certainly one of the worst portages in Wisconsin.

The dividing ridge between the waters of Lake Superior and the Mississippi, at this point, is upwards of 1180 feet above the level of Lake Superior; and is crossed by the trail about four miles north of Portage Lake.

From the last crossing of Montreal River to Portage Lake, a distance of six miles, no rocks were observed *in situ*. Both hills and valleys are covered with boulders of crystalline rocks, principally granite, intermingled with fragments of red sandstone and hornblende slate. The hills are covered with a growth of small timber, mostly pine, with some maple, oak, and a few aspens, while the valleys support a good growth of sugar maple, with undergrowth of the same. Within the last two miles, a number of small ponds were seen, a feature which, though very common in other sections, had not been observed before on any part of this route.

After leaving Portage Lake, we passed a series of small lakes, connected by shallow, winding streams, with numerous granite boulders in their beds, and finally entered Big Turtle Lake, from the east side of which there is a portage of about six hundred yards to Little Turtle Lake. At this place, we camped just in time to escape the rain, which had been threatening to fall all day, and now came down in torrents.

The country around these lakes, in its general features, differs from that north of the dividing ridge, in having a more sandy and lighter soil, while the conical hills have disappeared, and in their stead there are gentle swells, with dry valleys intervening, and all covered with a dense growth of hard and soft woods, showing the capability of the soil for supporting a luxuriant vegetation of a character suited to the climate.

September 25. Turtle Portage is an excellent one, over the plain lying between the two Turtle Lakes. At the east end of it is an Indian village, inhabited during the summer months by one of the Chippewa bands. Potatoes and corn are raised at this village. The soil is underlaid by fine drift, with occasional large granite boulders disseminated through it. Along the shores of the lakes, sections of drift, from ten to twenty-five feet in thickness, are exposed.

The outlet from Little Turtle Lake is through a very narrow channel connecting it with another lake, which we crossed, and came to the beginning of what is known as "Six Pause Portage." As the voyageurs had to make a double portage, we took our packs and walked on to its termination, at the east branch of the Chippewa River, or, as it is commonly called, the Manidowish, where we arrived at noon. The trail runs over a sand barren, with the exception of the last half mile, which passes through one of the worst tamerack swamps I have ever seen. A few stunted pines, with occasional patches of coarse grass, is the only vegetation supported on the high grounds.

The Manidowish River at this point comes from the northeast, is deep and clear, about thirty feet wide, and winds through the centre of a broad wet meadow, with grass from two to five feet high. After the portage was made, we descended the river four miles, though probably not more than one mile in a direct line from the portage to a favourable place for a camping-ground.

September 26. The river is exceedingly crooked, and from forty to fifty feet in width from the camp to the mouth of Lac du Flambeau River, a distance of three miles. Where the bends of the river approach the margin of the meadows, the banks are from four to six feet high, and composed entirely of a yellowish coarse sand, resembling very much that found on the Chippewa below the Dalles. Soon after entering Lac du Flambeau River, which we ascended to the lake of which it is the outlet, large boulders began to show themselves, some of them of great dimensions. One which was examined, measured fifteen feet in the long diameter, twelve feet in the transverse, and stood seven feet out of the water. It was composed of mica slate, and studded with garnets of small size.

Just before reaching a range of hills, the river runs through what was once evidently the bed of a large lake, now drained, and overgrown with aquatic grasses. Through this the river flows in many channels, some of them fifty yards wide. This alternate widening and narrowing of the river occurs all the way to the lake. The trunks of hundreds of dead tameracks are standing in all the spaces between the channels, and give a peculiar air of desolation to the scene, only partially relieved by the evergreens on the distant highlands.

About three miles above the mouth of Lac du Flambeau River, in a direct line, we came to a range of low hills, on either side of the wide meadows through which it flows, which gradually recede until they reach the height of from forty to eighty feet. One mile higher the rocks show themselves in place, and are composed of quartz rock, granite, and mica slate, with innumerable garnets disseminated through them. Disthène, tremolite, and crystals of hematite were also abundant in the slate, which dips 37° to the southwest. The rocks are in parallel ridges, the summits of which are from one to two hundred yards apart, and becoming more elevated as they trend to the northeast and southwest. The ridges are bare, with the exception of an occasional bush, and in the intervening valleys only a little coarse grass is found.

Shortly after passing this range the swamps again show themselves, and continue on either side of the river up to Lac du Flambeau. The river is exceedingly crooked, its general course being south-southeast. We reached the Lake late in the afternoon, and, crossing its northwest arm, camped near the old Trading-House of the American Fur Company, now deserted.

Lac du Flambeau is the largest body of water we have seen in this region. It is exceedingly irregular in its outline, resembling rather an assemblage of several small lakes, united by short narrow channels. It has a number of thickly-wooded islands dotting its surface. The shores recede with a gentle slope, to the height of twenty and thirty feet, and are covered at some points with bushes and grass, and by a dense forest at others. The soil, like that in the neighbourhood of Turtle Lake, is a light sandy loam; and, judging from its general appearance, would hardly

attract the attention of a cultivator. The Indians, however, who have a village on one of its shores, raise excellent potatoes; better, indeed, than are usually grown, with all the aids of cultivation, in the valley of the Ohio. The arm of the Lake, near which we encamped, is called by the Indians *Pokegoma;* a name given to any lake connected with another, or with a running stream, by a very short outlet.

September 28. The Pokegoma arm of Lac du Flambeau, which we crossed this morning, is about three and a half miles long by half a mile in width. It abounds with fine fish, which the Indians take in great numbers in gill-nets and with the spear. From the northeast shore of this lake a portage of half a mile, over sand-hills, covered with small pines, and elevated about thirty feet above the general level of the small lakes, leads to Lake Wepetangok, which we crossed in a high wind. This lake is about two miles long, and our course across it was northeast, to a small channel, four feet wide and eight yards long, which led us into another small lake, three-fourths of a mile long and half a mile wide, which we crossed northeast, to a portage of one mile in length, leading to Mashkegwagoma Lake. This portage passed over hills of the same character as those seen in the morning.

We waited some time on the shore of this lake for the wind to subside, and at noon started across. By the time we had made two-thirds of the passage the wind increased to a perfect gale, and wave after wave, which ran almost as high as I have ever seen them in Lake Superior, broke over our canoe, until it was more than half full of water, and in momentary danger of sinking. By great exertions, the men succeeded in reaching the borders of a small island, and we dragged the canoe into a marsh. Everything was thoroughly soaked, with the exception of my note-books, which, very fortunately, were secured on my person. A fire was built in a spruce thicket, the highest part of the island, and we set about drying our persons, clothes, maps, and instruments. As the wind continued high all the afternoon, we were forced to camp on the island. The lake is about two and a half miles long and one mile and a half wide, a very small sheet of water to afford so heavy a swell. Our misfortune is to be attributed, however, more to the size of our canoe than to the roughness of the lake.

September 29. Crossed to the main shore, and made a portage of a mile and a half, to the Chippewa or Manidowish River. The trail, for nearly the whole distance, leads through swamps flooded with water almost ice cold. The river at this point is about forty feet wide, winding to the northwest through marshes like the one just passed.

Had it not been desirable to visit Lac du Flambeau, we might have reached this point by ascending the river from "Six Pause Portage," through "Cross" and other small lakes; and this was the route pursued by Mr. A. B. Gray and party, in 1846, as I have since learned. I knew nothing of the route, however, at that time. It is the one commonly followed by the Vieux Desert and Trout Lake Indians, in passing from their villages to La Pointe, and is, in every respect, preferable to the one pursued by us, for persons wishing to pass from the head of Wisconsin River to the neighbourhood of Montreal and Bad Rivers, or to any point northwest of Lac du Flambeau.

While the men were sent up the river with the canoe, Mr. Gurley and myself

took the trail for Trout Lake. The portage is an excellent one, about four miles and a half long, and passes for some distance over a sandy plain supporting a few scattering pines. The surface of the ground is literally covered with the winter-green, and the general features of the landscape resemble very much those seen in the neighbourhood of Lac Courte Oreille. About half way on the portage, we ascended a hill of drift, between forty and fifty feet in height, with a great number of crystalline boulders and a few large fragments of sandstone scattered over it. From the top of this hill a range of highlands were seen in our rear, distant eight or ten miles, bearing northeast and southwest. From their position and course, we judged them to be a continuation of the range seen in ascending Lac du Flambeau River. The drift continues on the Trout Lake.

About one mile before reaching the lake, the river becomes very shallow, and is so much obstructed by boulders as to require a portage to be made. There is an Indian village at Trout Lake, which is only occupied, however, during the summer and fall months. They have gardens for corn and potatoes at this place, though their principal dependence for food is upon the lake, which yields them a plentiful supply of fine fish. We received from an Indian here a lot of very fine potatoes, a most acceptable present, as more than two-thirds of the provisions we had brought from La Pointe were consumed, and we had not yet performed more than one-third of our journey.

Trout Lake is seven or eight miles long by about four miles wide, and contains a number of small islands. It is surrounded by drift hills, from twenty-five to forty feet high, supporting a sparse growth of small pines and birch. Our course across it was northeast, to a trail leading to Lower Rock Lake. We encamped on the trail, a short distance from the lake. At six o'clock, P. M., the thermometer stood at 31° Fah., and our tent and baggage, which had got wet in crossing the lake, were frozen.

September 30. Ice formed one-fourth of an inch thick last night. The portage between Trout and Lower Rock Lakes is about two miles and a quarter in length, and runs along the base of drift hills. These lakes are connected by a small stream, not navigable for canoes. The Lower Lake is about half a mile in diameter. A portage of three hundred yards leads to Upper Rock Lake, which is one mile in its largest diameter, and contains a number of small islands. These lakes are also connected by a small stream. They derive their name from the immense number of boulders which line their shores, and show themselves above the water in the shallow parts. The islands, in the upper one, are made up almost entirely of boulders, with a thin soil covering them, and supporting a few small trees. Some very large masses of syenitic granite, hornblende, and greenstone, with smaller ones of amygdaloid, were seen near the east end.

We had great difficulty in finding the portage from this lake. It begins on the northeast shore, and is about two and a half miles long. Its course is nearly due east, passing a good part of the distance along the margins of cranberry marshes. Three small ponds were passed in the first two miles. They are connected by a small stream flowing into Upper Rock Lake, which is navigable for canoes up to the second pond. From this point a portage of everything has to be made to

Lower White Elk Lake. The country passed over yesterday and to-day is made up of drift hills, from twenty to sixty feet high. The sand is white and coarse, while the boulders, which are disseminated through the upper part, were derived almost entirely from granitic rocks. The soil is thin, but supports a growth of small pine, poplar, birch, spruce, hemlock, fir, a few oaks, and some bass-wood; the swamps, as usual, being filled with tamerack, or, where that is wanting, overrun with cranberry bushes.

Lower White Elk Lake, where we camped, is about three-quarters of a mile long and a quarter of a mile wide. Here we found a number of deserted wigwams and the remains of a garden. The lake affords great numbers of fish, and the quantity of their remains scattered around shows they are the principal article of food among the Indians who occasionally inhabit it.

October 1. A very heavy frost this morning; the thermometer standing at 25° Fah. at half-past six o'clock. We crossed First White Elk Lake, and, by a stream twenty feet wide and a quarter of a mile long, passed into Second White Elk Lake, which is about two miles long and one mile wide. From this we passed into Third White Elk Lake, by a stream ten yards wide and three hundred yards long. This lake is nearly circular, and about one mile in diameter. It is very shallow, not having a depth of more than three feet at any point, and has a mud bottom. We noticed here a phenomenon, not hitherto observed in any of the great number of small lakes we have seen in the territory. The whole surface of the lake was covered with bubbles of light carburetted hydrogen gas, which were constantly ascending from the bottom.

From this lake, a portage of a quarter of a mile brought us to the Fourth White Elk Lake. The portage leads due east, over drift, covered with a better soil than any met with for several days past. It supports a tolerably good growth of sugar maple, birch, oak, poplar, and a few pines. This lake is a beautiful sheet of water, about one mile long and three-fourths of a mile wide. The bottom is covered with pebbles and the shore with boulders, some of which are very large; one of them being over fifty feet in circumference. This is the source of the east or Manidowish branch of Chippewa River; all the lakes and streams beyond this point, which send their waters to the Mississippi, being tributaries of the Wisconsin. The hills bounding the north and east shores, are about one hundred and fifty feet high, and are composed of white sand, with occasional boulders scattered over the surface. Almost all the boulders seen, for the last three days, were granitic and small. To-day, however, at the Fourth Elk Lake, boulders of other rocks were numerous, and, from the size of some of them, I infer that the source from which they were derived is not very distant.

The portage to the head-waters of Wisconsin River starts due east from this lake. In about half a mile the trail divides, the left-hand branch leading directly to Vieux Desert Lake, the other to a small lake which discharges its waters into the Wisconsin, about ten miles in a direct line south of Vieux Desert. We determined to take the shortest route, principally on account of the little provisions we had remaining, and the certainty that they would be exhausted before we could reach any point where supplies could be had.

The portage is about six miles long, over a high, rolling pine country, which does not afford a drop of water, from the Upper White Elk Lake to within a quarter of a mile of the end of the portage, where a small stream, ten feet wide, from the northwest, crosses the path.

The high and broad strip of land which divides the waters of the Chippewa from those of the Wisconsin is made up of white sand, with small boulders thinly scattered over the surface. The pines with which it is covered are small, but very tall and straight, many of their trunks rising fifty or sixty feet without a branch. On some of the higher hills a great many small birch were seen; and in the vicinity of Muscle Lake the sugar maple began to appear.

October 2. The ground was whitened by a heavy frost, and the atmosphere cool and bracing. Muscle Lake, upon which we began our voyage to the Mississippi, is about one mile long and rather more than half as broad. A small stream, about one hundred and fifty yards in length, led us into another lake, rather more than half a mile in diameter. It discharges its waters into the Wisconsin River, through a small creek, from one to five yards wide, running east. The creek is very shallow, very crooked, and much obstructed by drift wood, but without a rock of any description. Its whole course is through swamps, bordered by sand-banks covered with pine. The banks have quite a reddish appearance, although the sand in the bed of the river is white. The entire bed of the creek, in many places, is covered by several species of Unio.

At half-past twelve o'clock we entered Wisconsin River, which is twelve yards wide at the junction, and from three to four feet deep. Its course is south for several miles, but gradually changes to southwest, which was the prevailing course during most of the afternoon. We encamped about eighteen miles below the mouth of Muscle River, although in a direct line, probably, not more than six or seven miles, as the river is remarkably crooked. It is from ten to fifteen yards wide, and is occasionally obstructed by drift-wood. We did not see a rock or pebble of any kind, until just before reaching our camping-ground, when a solitary boulder showed itself; and, a few minutes afterwards, the shores were found lined with pebbles, washed out of the banks, which are composed of sand, and are from three to twenty feet high, and covered with pine, fir, and spruce, with a few aspens and small birch. The low grounds, which frequently intervene between the river and the high banks, support elm, and, where very low, tamerack in abundance. The margin of the water is overhung by alders and cranberry bushes. At one point the drift was seen resting on a bed of reddish-coloured indurated clay. The banks, where slides have taken place, present all the appearance of stratification, with a dip to the south greater than the fall of the river. A few first-rate and many second-rate pines were seen.

October 3. We left camp at 8h. 30 min. this morning, and at 1h. 30 min. reached the first rapids. They are made by a low range of gneiss and gneissoid granite, bearing northeast and southwest, and are half a mile long. The fall is not very great, but the navigation was rendered rather difficult by the great number of boulders, some of them very large, which cover the bed of the river for nearly the whole

distance. Above the rapids the river is fifty yards wide; below them it contracts again to thirty yards in width.

Three other rapids occur in the distance of a mile and a half. The first one is short, but difficult to pass. The river is divided by a small island at the foot of the rapid. The channel for canoes is on the east side of the island. The second one is made up of granite, with gneiss resting on it; and the third of gneiss and hornblende. In the forenoon the river was much obstructed by drift-wood, and was very crooked, except in the vicinity of the rapids, where its channel lay, for some distance, between the elevated ridges of rock. The country for a short distance above and opposite these rapids is open, bearing thickets of small birch, and a few stunted pines scattered through them. Occasionally, a solitary large pine was seen standing on a sandy knoll, twenty or thirty feet above the level of the river. Below the last rapids the country is made up of sand, apparently destitute of pebbles, with sandy loam on top, and supporting a tolerably good growth of pine, birch, and aspen.

October 5. Ninety-six miles (according to our estimate of distances) below the mouth of Muscle River, we came to a high range of rocks, consisting of hornblende, gneiss, and gneissoid granite. This range is about one hundred and fifty feet high, bearing northeast and southwest. The rapids formed by it have a descent of about thirty feet in a quarter of a mile. The portage path is on the east side of the river, and is about five hundred yards long.

On a small prairie, half a mile from these rapids, I measured a granite boulder, seventy-eight feet in circumference, and ten feet high.

The rocks continued to show themselves until, ten miles below the last range, we came to one about three hundred feet high, composed of syenite and greenstone, traversed by veins of felspar, quartz, granite, and titaniferous iron. The granite veins are from two to three feet in width, and porphyritic.

The average width of the river yesterday was from forty to fifty yards. The banks were of sand, from ten to thirty feet in height, and exhibit, at some points, extensive slides, similar to those seen on the Chippewa, below the Dalles of that river.

I made an excursion into the country yesterday, commencing at the foot of a large island, the first one of any size met with in descending the river. I proceeded directly west, and found the country to present a succession of low ridges and tamerack swamps. The ridges are sandy, with a thin soil, and from a quarter to half a mile wide. On the more elevated grounds are some first-rate, and a great number of second-rate pines.

A few miles south of this, the Kewaykwodo Portage begins. It passes, for some distance, over a rolling sandy country, which is the general character of the region bordering the river for some miles above and below the beginning of the portage. A narrow strip of small pines lines the banks of the river at intervals; but, as you recede into the country, there are few trees of any size to be seen. Clumps of very small birch and pine are scattered over it. This portage leads to Lac du Flambeau, by way of Swamp, Kewaykwodo, Leech, Sheshebagomag, Mishekun, and La Roche

qui Traine Lakes. Just below the Kewaykwodo Portage, the river is filled with boulders, some of which are very large.

The banks of the river to-day were of fine drift, generally from three to eight feet high, and resting on a bed of red clay, the thickness of which is not known, as it only rises from twelve to eighteen inches above the water-level. It is stratified, exceedingly compact, and in seams about an inch thick. Some of the ridges, sections of which are made by the river, are from fifty to sixty feet high, and composed entirely of sand, with pebbles and a few small boulders near the top.

October 6. About eight miles below the last high range, we came to one about one hundred and fifty feet high, composed of the same kind of rocks,—syenite and hornblende. The rapids at this place are half a mile long, with an island dividing them at the lower end. At the foot of the island, the water falls two and a half feet perpendicular. There is a portage path on the east side of the river. One canoe, however, descended the rapids without much difficulty.

There is a succession of small rapids for the next four miles, the rocks showing themselves in the borders of the river, at short intervals, the whole distance. The river is very shallow, very wide, and the bed covered with boulders, many of which are from thirty to fifty feet in circumference. In the afternoon, we reached a point where the river is from four hundred to five hundred yards wide. Up to this point it has been so shallow, below the last rapids, as to allow the canoe to pass with difficulty. Here it is deep, with no perceptible current, and continues so for about six miles, when it is again obstructed by boulders and a succession of rapids, which continue for about eight miles, the rock showing itself in place, at several points, in the middle of the river. The rocks are fine-grained granite, hornblende, and porphyritic syenite, in low ranges, all bearing northeast, and traversed by wide quartzose veins. The country, with the exception of the rocky ranges, is, in the immediate neighbourhood of the river, mostly broken sand prairie, with a few small pines scattered here and there; and, occasionally, a few shrubby oaks, small birch, and aspen, show themselves. The ridges are densely timbered with hard and soft woods; among which, when the rocks approach the surface, a great deal of fine cedar is found. The river bottoms, which are sometimes from a quarter to half a mile wide, are timbered with oak and elm of good size, or covered with a luxuriant growth of grass.

October 7. We left camp this morning at seven o'clock, and two miles below came to a low range of trap rocks, bearing northeast and southwest, and making rapids. One mile below this, we reached the largest rapids of Wisconsin River, known among the traders and lumbermen as "Grandfather Bull Falls." A fine section is exposed at this place. The top of the ridge is about one hundred and fifty feet above the level of the water, which cuts through the rocks for the distance of a mile and a half. The fall of the water in this distance I had no means of ascertaining. At the upper part of the rapids, the river is divided into three chutes, by two chains of rocks, which rise from ten to fifteen feet above the water, and continue for some distance below the commencement. The rocks on the north side of the range are greenstone trap, protruding through gneiss and hornblende slate; while the lower part of the rapids is made by gneiss, interstratified with mica slate and

talcose slate. The stratified rocks above the rapids have a dip of 20° to the northwest. The river falls, for a great part of the distance, in a succession of small cascades, made by the tilted strata extending across the river in the line of bearing. A few of the cascades are seven or eight feet high, but generally from two to five feet, and from sixty to eighty yards apart. At the foot of the falls, the gneiss and mica slate dip 57° south-southeast.

Four miles below the falls, we reached the mouth of Skakweya or New Wood River; and, much to our joy, found a trading-house established there. The person who occupies it intends opening a farm, and has already made a small clearing. We obtained from him some pork and a lot of fine potatoes. As we had been without meat for several days, we found the sour pork quite palatable. The potatoes, which were raised here, are equal to any I have ever seen.

About a mile and a half below the mouth of New Wood River, a number of springs, strongly impregnated with iron, burst out of the west bank of the river. As the springs are but a few feet above low water-mark, every rise of the river carries away most of the ferruginous matter deposited; still there is a deposit of considerable thickness lining the shore for the distance of a quarter of a mile. The hill in which the springs originate is about eighty feet high, and extends back from the river from a quarter to half a mile, to a deep ravine, into which springs discharge from the same hill, but present no indication of iron whatever.

At the mouth of Copper Rock River, five miles below the mouth of New Wood River, a trap dike crosses the Wisconsin, making an island in the river thirty feet high, known as "Rock Island." This range makes dalles on Rock River, several miles above its mouth. The walls of rock at the dalles are from forty to fifty feet high, and, at one point, approach within six feet, through which contracted space the water rushes with great swiftness. There is a portage of twelve miles from the mouth of the river to a point above the dalles; the river is then navigable for canoes to the lake, of which it is the outlet, a distance of about forty miles. Greenstone continues to show itself in the river, without forming rapids, for the next three miles.

Six miles below the mouth of Rock River, Prairie River comes in from the east, and just below its mouth a range of hornblende trap crosses the Wisconsin, bearing east-southeast and west-northwest, forming "Beaulieux's Rapids." At one point in these rapids there is a fall of four feet, affording excellent facilities for driving machinery.

Seven miles below these rapids, near the mouth of Pine River, trap shows itself in the bed of the river, without obstructing navigation. About four and a half miles below the mouth of Pine River, "Trap Rapids" begin, and immediately below them a reddish-coloured, compact, fine-grained granite, shows itself in the banks of the river. Three miles further, a range of hills, from three hundred and fifty to four hundred feet high, and bearing northeast and southwest, skirt the river for some distance. They are, so far as observed, made up entirely of a greenish-coloured compact, petrosiliceous rock, fusible, with difficulty, before the blowpipe into a colourless enamel, and resembles very much some trachytic specimens brought from the Euganean hills, and from the Cantal. This rock extends to within a short

distance of "Big Bull" Falls, and forms the most southerly range of hills in the eastern part of the Chippewa Land District, the corner of which strikes Wisconsin River in latitude 45°, and about six miles above the Falls.

We got to the Falls early in the afternoon, and having made the portage around them, devoted the remainder of the day to procuring provisions for the further prosecution of our journey.

The village at the Falls consists of a number of very good frame houses; and from its position, with regard to the lumber trade, in connexion with the productiveness of the soil in its vicinity, bids fair to become a place of considerable importance at no distant day. An effort is being made to lay out and open a road from Green Bay to this place, which, when completed, will materially accelerate the settlement of the country, not only by affording facilities for emigration, but also by reducing the cost of provisions, which, at present, is a serious matter to new-comers, who have to purchase almost everything for the first year.

One of the finest pine regions of Wisconsin enters the District at this point, from the south, and extends for some distance above Spirit River. The general character of the lands bordering Wisconsin River from near its source to the neighbourhood of "Grandfather Bull's Falls," has been indicated. Below that point, from a quarter of a mile to a mile back from the river, ridges, bearing maple and other hard woods, begin and extend back into the country for many miles, while between the river and maple lands good pine is abundant.

The rivers originating in the Chippewa Land District, down which logs can be run, are "Rib," "Trap," "Rock," and "New Wood" Rivers. On all these streams first-rate pine abounds, and on all of them "Logging Companies" have been established. The country between them is made up of maple ridges, interspersed here and there with marshes.

"Big Bull Falls" are made by a ridge of syenitic granite, about thirty feet high, traversed by a dike of greenstone, and crossing the river with a bearing east-northeast and west-southwest. The river is divided by an island, upon which three mills are erected. The perpendicular fall of the east chute is about four feet, that of the west chute about eight feet. The rocks have a dip of 24° to the northwest.

October 9. Seven miles below "Big Bull," a high granite range shows itself on the west side of the river; and at several other points, between that and "Little Bull Falls," a distance of thirteen miles, are exposures of the same rock.

At "Little Bull" there is usually a portage made, three-quarters of a mile long, on the west side of the river, but our voyageurs descended the whole rapid in the canoe, with the exception of a few yards at the mill-dam. There is no perpendicular "fall" at this place; it is a mere rapid, falling, in its whole length of over half a mile, as nearly as I could judge, eight or ten feet. The rock is a dark grayish and greenish-coloured compact syenite. The range is rather low, the rock being elevated, at the highest points observed, only about ten feet above the water-level.

October 10. Nine miles below "Little Bull," a low range of gneissoid granite is exposed, extending along the western shore of the river for the distance of one hundred and fifty yards, bearing east-northeast, and west-southwest with a dip of 6° to the south-southeast. The rock is traversed by numerous quartz veins, from

one to four inches wide, and running in the direction of the line of strike. The direction of the cleavage joints is 15° west of south, and due east and west. The rock is overlaid by twenty feet of fine drift, with a thin soil of sandy loam.

The country is gently undulating prairie, with clumps of very small pines scattered over it.

One mile below this we reached Du Bois's Trading-House. About five miles below Du Bois's, the grayish-coloured gneissoid granite is again exposed for some distance along the west bank of the river, succeeded by a very fine-grained reddish granite. The rock is covered here with about ten feet of fine drift, with a thin soil, supporting a small growth of oak, elm, and aspen, on the west side, while east of the river a beautiful undulating prairie extends as far as the eye can reach.

One mile above Stevens's Point there is an exposure of hornblende slate for half a mile, succeeded by gneissoid granite, which extends for some distance below the Village, forming rapids. The bearing of the rocks is northeast and southwest.

The country in the vicinity of this place is undulating, with a tolerably good soil, supporting a growth of oak, elm, maple, and a few pines.

Two miles further brought us to Conant's Rapids. This point is exceedingly interesting, not only on account of the great exposure of rock, but also in consequence of the foldings and contortions which have been produced in the stratified rocks, at the time of the intrusion of the igneous rocks. The prevailing rock is a very decomposable amphibolic gneiss, passing into a highly ferruginous mica slate, green, brown, and reddish gray, in different localities, and associated also with a very light-coloured granitic gneiss. These rocks all have a vertical dip, and are compressed by lateral force into almost every possible wavelike form. Between the layers of gneiss, veins of felspathic granite, from six inches to twenty-five feet in width, have intruded at intervals, and, at many points, overlies for a long space the vertical edges of the gneiss. Some of the veins are porphyritic. The direction of the plane of stratification is northwest and southeast. Numerous veins of quartz and of felspar, from an inch to an inch and a half in width, traverse both the stratified and intrusive rocks, and have a northeast and southwest direction. Camped one mile below the commencement of the rapids.

October 11. There is a fine display of gneiss on an island opposite our camp. It is a gray-coloured, very fine-grained, compact rock, with a few regular crystals of felspar disseminated through it, bearing east-northeast and west-southwest, with a dip south-southeast of 19°. It is traversed by many granitic veins, following the curvatures of the strata; and these veins are traversed in turn by veins of quartz, from half an inch to an inch wide, having a northeast and southwest direction. The gneiss is overlaid for a considerable space, at many points, by a very fine-grained, reddish-coloured granite.

About two miles below Conant's Rapids, and about one-fourth of a mile below the mouth of Plover River, the gneiss is again exposed, bearing northeast and southwest, with a dip of 45° southeast. There is no bending of the strata at this place, nor did I observe any intrusive rock. Below the mouth of Plover River, the drift banks rise, on the east side of the Wisconsin, to the height of thirty and fifty feet above the level of the water; and, at the bends of the river, sand-slides occur, pre-

cisely like those seen on Chippewa River, some of which are more than half a mile in length. Very few pebbles are mixed with the sand. The country is a rolling sand-plain, with a few pine bushes and dwarf oaks scattered over it.

The next exposure of rock is at the commencement of the Grand Rapids, about twelve miles below the mouth of Plover River. These Rapids are nine miles long. Their "grandeur" consists not in cascades or bold escarpments, but in their length, and the great number of low, picturesque rock-islands, covered with trees, which dot the river, and divide it into numerous narrow channels or chutes. The rock is a very compact felspathic gneiss, with occasional wide veins of granite traversing it; gradually assuming a true porphyritic character about the middle of the Rapids; and, toward their termination, merging into a gneissoid granite; and, finally, at the village of "Grand Rapids," into a fine-grained, reddish-coloured granite, of precisely the same character with that which overlies the gneiss at Conant's Rapids. The bearing of the rocks is east-northeast and west-southwest.

The village at this place contains a number of good houses, and, from the air of business and comfort about it, I should judge it to be a prosperous one. There are three mills on these Rapids, which give employment, directly and incidentally, to a large number of men. The river banks in the vicinity are low. The country is covered with a good growth of oak, elm, poplar, birch, sugar maple, and pine.

October 12. There was a light fall of snow last night, and the sprinkling of pure white on almost every variety and shade of colour of autumnal foliage, intermingled with evergreens, combined, with the wooded islands in the distance, the Rapids, with their rocky projections, in the foreground, and the dense forest on either shore, to make up one of the most picturesque and fairy-like scenes imaginable.

The river, for some distance below this point, is full of rock-islands, rising from ten to fifteen feet above the water-level, and made up of a reddish-coloured rock, composed of quartz and felspar, bearing northeast and southwest, with a dip of 39° to the southeast.

About eight miles below the camp of last night, we reached Whitney's Rapids; the rock, during the whole distance, being a felspathic granite, with little or no appearance of mica in its composition; and, as the Rapids are approached, showing a great disposition to decompose on exposure to atmospheric influences.

The last exposure of granite on Wisconsin River is a short distance above the old mill-dam, at these Rapids, and extends down the river for the distance of a quarter of a mile, gradually becoming more quartzose in character, and at the point where it disappears, is traversed by many felspathic veins, from one to eight inches wide, having a northwest and southeast direction.

Above the granite, at the old mill-dam, is a bed of ferruginous argillite, four feet thick, succeeded by five feet of decomposing felspar, above which is a bed, two feet thick, of well-digested kaolin, or porcelain clay, with large amorphous crystals of quartz disseminated through it in veins, and containing a notable quantity of pyrites. Then succeeds a variegated white and yellow sandstone, in thin laminæ, from the sixteenth of an inch to an inch in thickness, rather coarse-grained, somewhat micaceous, and weathering easily. Some of the laminæ are green, and the whole dips 4° to the southeast.

A quarter of a mile below the old dam, on the east side of the river, the sandstone forms a mural escarpment, of thirty-five feet in height, in strata of from two to eight feet thick. On the west bank, opposite this section of sandstone, the most southerly exposure of crystalline rocks on this river rises to the height of six feet above the water, and is composed of a quartzose granite, containing magnetic oxide of iron.

October 13. At one o'clock we reached Petenwell Peak, thirty-two miles below Whitney's Rapids. The country between these two points resembles, in almost every respect, that seen below the Dalles of the Chippewa River. The river winds through sands, rising forty and sixty feet above its level, and presenting in its bends extensive slides, from a quarter to half a mile in length. It is very crooked, and the channel is rendered somewhat intricate by the great number of sandbars, which change their position with every rise and fall of the river. Like the region alluded to on the Chippewa, the country is a succession of sand-plains, rising in low terraces, covered with a short, coarse grass, and having a few small pines and shrubby oaks scattered over it.

About half a mile before reaching Petenwell Peak, that huge mass of rock suddenly presented itself down a reach of the river, rising above the level sands to the height of two hundred feet, or more, and presenting, in every respect, the semblance of a work of human hands, now dilapidated and in ruins. It required no excited imagination to see, in this extraordinary mass of rock, the remains of some ancient stronghold. There were the massive walls, defined and regular in their outline, battlements, towers, buttresses, surmounted by towering pinnacles, deep, dark windows, and, in short, everything necessary to render the delusion perfect.

The base of the peak is an oval, about three hundred yards in the long, and one hundred yards in the short, diameter. On the east side, the rock is almost perpendicular, and is washed at its base by the river. On the north side, a small creek comes in from the west, close to the rock. On the south and west sides, there is a very abrupt slope from two-thirds the height of the rock to the general level. This slope is made up of sand and huge fragments of stone, with small pines scattered among them. The upper third is a perpendicular wall of rock, split into towers and turrets, and which I did not ascend. The prospect from the point which I reached is very extensive, embracing an expanse of country probably from forty to fifty miles in diameter.

The general appearance of the country from this elevation is that of a level or gently undulating plain, dotted here and there with groves of small oak and pine. But on every side, as far as vision can reach, other isolated peaks are seen rising from the plain. One towards the northeast, and distant probably twelve or fifteen miles, is apparently higher than Petenwell; and others, in different directions, from their appearance in the distance, no doubt equal it in height. To the southwest, on the verge of the horizon, there appears to be a connected chain of hills. In no other direction, however, is there the slightest appearance of connexion between the elevated masses, each one standing "solitary and alone," and miles from its fellows.

The rock is a light-coloured, coarse-grained sandstone, made up of perfectly

rounded grains, many of which are limpid quartz, and cemented together with considerable firmness. Some of the strata are banded with white and brownish-yellow stripes.

About six miles below Petenwell Peak, there is an exposure of fourteen or fifteen feet of sandstone, in the east bank of the river. Seen from a distance, it reminded me forcibly of the "Pillared Rocks" of Lake Superior. Some of the layers are soft and friable, while others are hard, and weather with difficulty. The current of the river, which continually washes the rock, has cut away the softer layers, leaving the harder ones standing out in relief, in the shape of rude cornices, while the rills produced by rains falling on the sandy slope above, and trickling down the rock at intervals of from five to twenty feet, have divided the cornices into capitals, and the rock below into pillars, so that it has, when seen from a distance, altogether the appearance of a magnificent colonnade, nearly a quarter of a mile in length, with the base of the columns resting in the water. There is a great difference in one respect, however, between the Pillared Rocks of the Lake and those of the Wisconsin. While the first, generally small in diameter and graceful in form, support an entablature often forty or fifty feet in depth, and crowned with noble forest trees, the latter, huge and massive in proportions, are capped by three or four feet of sand, bearing a few stunted shrubs, as worthless as the soil from which they spring.

October 14. Nine miles below the last exposure of rock, thin shaly layers of sandstone appear, just above the margin of the river, for the distance of half a mile; and four miles further, the rock rises to the height of twenty-five feet, in layers from six inches to five feet in thickness, variegated with red and yellow bands, and having very soft pulverulent nodules of oxide of iron, as large as walnuts, disseminated through some of the layers. The rock dips 4° to the southeast, is rather fine-grained, and contains a considerable proportion of greenish-coloured grains, not, however, in sufficient quantity to impart a greenish hue to any of the layers.

Two miles below this place, Fortification Rock rises to the height of more than a hundred feet above the general level. It stands on the west bank, about one hundred yards from the main channel of the river. The northwest side, which is one hundred and twenty feet long, is perpendicular, while it descends, on the southeast side, by a succession of narrow terraces, to the general level. The top presents an almost unbroken outline, while the front is singularly weathered, at a number of points, into semblances of windows and loopholes.

Below this place, the rocks are almost constantly exposed, on one or the other side of the river, rising to the height of forty or fifty feet, sometimes pillared, generally mural, and with a constant dip to the southeast of from 3° to 4°. Some of the strata have numerous cross-lines of deposition, are thinly laminated, and present a very remarkable appearance; the angle formed by the joints of the laminæ and those of stratification, ranging from 10° to 23°. In some of the layers, the laminæ are parallel with the plane of stratification; in some they are waved, and in others oblique; in some the materials are fine, in others coarse: showing the changeable direction and force of the currents by which they were deposited. I

observed strata of precisely the same character in the sandstone of Chippewa River, and occupying, apparently, the same position in the series.

At two o'clock, we reached the chain of hills descried from Petenwell Peak. They consist of sandstone, of the same character with that seen yesterday and to-day, with the exception of the upper layers, which, for the thickness of twenty-five or thirty feet, are white and sugar-like, and when struck with the hammer crumble into sand, rendering it somewhat difficult to procure and transport specimens. These cliffs differ from those seen yesterday, in presenting on one side a nearly perpendicular face, from two hundred to three hundred feet high, while on the opposite side they descend, by long and very gradual slopes, to the general level. They rise at long intervals, being separated by wide ravines, sparsely wooded, and are distributed along the country like a cordon of forts. Many, indeed most of them, resemble, when seen from a distance, artificial works; and one who has seen them feels no surprise that the superstitious Indian should consider them dwelling-places of superior intelligences, and look upon them with awe and reverence. Although the materials of which they are composed possess little coherence, and are separable by a slight force, they will resist the siege of the elements for centuries yet, and remain to mark the boundaries of cultivation, which can never encroach upon the sterile wastes encircled by them.

Two miles further brought us to the Dalles of the Wisconsin. The walls of sandstone forming the Dalles are from twenty-five to eighty feet in height, and from fifty to one hundred feet apart. Between these perpendicular walls the river flows for some five or six miles, its average width being about one hundred feet.

Although it was quite as low as it was ever known to be, scarcely affording, in many places, sufficient water to float a canoe, in the Dalles it was deep, and the shadows of the rocks gave the water an almost black appearance. The current was gentle, and often almost imperceptible, and the bed, so far as I could judge, free from loose masses of rock. When the river is high, and especially during freshets, it is a passage of great dread to the "raftsmen," in consequence of the many short turns and projecting points around which the raft is swiftly hurried by the current, which then forces its way through the long defile with the speed of an arrow, being greatly accelerated by the great head of waters which accumulate above the entrance, forming quite a lake, and pressing to enter the narrow gorge.

The weathering of the laminated strata, before alluded to, with their exposure to the action of the current in different directions, and the cutting of the joints in varying lines, are productive of singular and beautiful effects. Architraves, sculptured cornices, moulded capitals, scrolls, and fluted columns are seen on every hand; presenting, altogether, a mixture of the grand, the beautiful, and the fantastic.

The dip of the rocks here is 3° to the southeast. The country is rolling, and the sands are covered by a thin soil, supporting a growth of small oaks.

October 15. Eighteen miles below the Dalles, we passed "Winnebago Portage," which leads to Fox River of Green Bay, and was, for many years, the route by which all the goods intended for the trading-posts at Prairie du Chien, and other points on the Mississippi, passed, in their transportation from Mackinaw. It may

be considered the head of steamboat navigation on this river. Occasionally, fine sections of sandstone were displayed in the bluffs to-day, rising from thirty to one hundred feet above the water-level.

A short distance above Sauk Prairie, I noticed, for the first time on this route, the Lower Magnesian Limestone, overlying the sand-rock, which reaches, in the course of the river, from Whitney's Rapids to this place. At the junction of the two rocks, they present a very peculiar banded appearance, when exposed in mural cliffs, owing to the intercalation of thin layers of the two formations, and their weathering unequally.

At this point my geological observations ceased; the object of the reconnoissance having been to trace the rocks from Lake Superior to their junction with the Protozoic Sandstone of the Mississippi Valley, and make incidental observations on the topography of the country. Having accomplished these objects to the best of my abilities, I hastened toward the rendezvous at Prairie du Chien, where we arrived on the morning of the 19th October.

SECTION III.

NARRATIVE OF EXPLORATIONS MADE IN 1848, ALONG A PORTION OF THE NORTH SHORE OF LAKE SUPERIOR, AND ON LEFT-HAND, ST. LOUIS, UPPER EMBARRAS, VERMILION, RAINY LAKE, BIG FORK, AND THE NORTHERN MISSISSIPPI RIVERS.

On the 10th of June, I received, at the mouth of Crow Wing River, your final instructions, regarding my field of operations for the season, and the nature of the reconnoissance to be made along the north shore of Lake Superior. As the geography of the northern portion of the District was but little known, and as the geological exploration of this country would be far in advance of the linear surveys, the Department had determined to have the position of important points determined, as nearly as might be, by astronomical observations with the sextant and chronometer. This especial duty was assigned to Colonel Charles Whittlesey, the result of whose labours has already been communicated to you.

We were detained at the mouth of Crow Wing River nearly a week after your departure for Red River of the North, in consequence of our inability to procure canoes and a sufficient number of voyageurs. Our first intention was to ascend the Mississippi to Cass Lake, and proceed thence to Rainy Lake, by way of Red Lake; and from that point to cross the country to Lake Superior, by way of Vermilion Lake. But, on making an estimate of the length of time which would be required for such a journey, it was obvious that the small lot of provisions we had brought with us would not last beyond Rainy Lake River. As there was little probability of our being able to obtain supplies at either Red Lake or Rainy Lake River (which we subsequently ascertained we could not have done), and none could be procured at Crow Wing, we determined to reverse the projected line of exploration, and proceed immediately to Lake Superior; and, after having made a reconnoissance of that portion of the north shore of the Lake designated in my instructions, to pro-

cure supplies, which can always be had at La Pointe, sufficient for the remainder of the season.

In pursuance of this plan, we ascended the Mississippi to Sandy Lake, and crossed, by way of the West and East Savannah Rivers, to St. Louis River, which we descended to Fond du Lac Village. At this place, Colonel Whittlesey remained for the purpose of making astronomical observations, while I proceeded to examine the geology of Left-hand and Black Rivers. I then returned to Fond du Lac, and, with Colonel Whittlesey and Mr. R. B. Carlton, descended the Lake, along the north shore, as far as Two Island River. Between that point and "Fond du Lac Supérieure," as full a reconnoissance was made among the trap and metamorphic rocks, and for as great a distance from the Lake shore, as my instructions required, and the time allowed me permitted.

On our return to St. Louis River, we were joined by Mr. Basil H. Beaulieu, in the capacity of assistant and interpreter. After making arrangements with Colonel Whittlesey for the exploration of Aminekan and Poplar Rivers, I started to La Pointe, on the 31st of July. At that place, I obtained provisions sufficient to last the corps for three months, and then returned to Fond du Lac Village, where I was rejoined by Colonel Whittlesey; and on the 12th of August, we began to ascend St. Louis River. This stream was followed up to the mouth of Upper Embarras River, where we left it, and ascended the last-named stream to a point where the Indian trail, which crosses the highlands separating the waters of Hudson's Bay from those of Lake Superior, strikes it. By this trail, which is six miles in length, we reached the head-waters of Vermilion River, and descended that stream, through Vermilion Lake to Rainy Lake. Thence, we descended Rainy Lake River as far as the mouth of Big Fork River, the largest tributary of that stream.

We began to ascend the Big Fork, on our way south, on the 10th of September. Two days' journey from the mouth, Opimabonowin River, which heads in the direction of Red Lake, comes in from the west. It had been our intention to reach one of the northern tributaries of Red Lake, by ascending Opimabonowin River to a portage path used by the Red Lake Indians in their journeys to Rainy Lake and Lake of the Woods. At its mouth, however, we met an Indian who had just descended it, and the information derived from him satisfied me that, with our large canoes, the route was an impracticable one. It was determined, therefore, to continue up the Big Fork to one of its sources, and then reach Lake Winibegoshish by one of the northern tributaries of the Mississippi.

On the 19th of September we arrived at Lake Winibegoshish. Leaving one of the canoes at the Trading-House, in charge of a disabled voyageur, we proceeded by way of Cass Lake, Turtle River, and the chain of lakes described by Beltrami, to Red Lake.

From Red Lake we returned by the same route to Lake Winibegoshish; and thence descended the Mississippi to the mouth of Mud River. From that point I sent one of the canoes, with all the collections and most of our baggage, down the Mississippi, in charge of Mr. Beaulieu, with instructions to wait for me at the mouth of Rum River; while I, accompanied by Colonel Whittlesey, left the Mississippi, for the purpose of examining the Mille Lacs country.

We reached the vicinity of Mille Lacs by way of Mud River; and, by a short portage, arrived at the Lake, on the 7th of October. A day and a half was spent in examining the shores and islands of the Lake, and in making the observations necessary for determining its geographical position, when we proceeded by Rum River, which drains the surplus waters of the Lake, to the Mississippi, eighteen miles above the Falls of St. Anthony, where the field operations for the season terminated.

It will be perceived, from the above outline of the route, that the country traversed during that season embraced a large district of untrodden ground, so far as scientific objects are concerned, and was almost totally unknown, in all respects, except to a few agents of the Fur Companies, who occasionally cross some portions of it in their traffic with the Indians.

A great amount of chorographical information was obtained by personal observation, as well as from Indians and "half-breeds," who are thoroughly acquainted with the country.

1. *From Crow Wing River to Sandy Lake.*—In the summer of 1847, while engaged in exploring a portion of St. Louis River, I made an arrangement with Mr. Allan Morrison, a gentleman in the service of the Fur Company, and who is well acquainted with the Northwest Territory, by which he agreed to accompany me the next season in the capacity of assistant. In the latter part of the ensuing winter, he was directed to engage men, purchase canoes, and have everything in readiness for the corps to start from St. Peter's by the middle of May.

On arriving at St. Peter's, however, it was ascertained that Mr. Morrison's services were required by the Fur Company, and he could not fulfil his engagement. Neither had any arrangements been made towards securing an early entrance of the corps into the field. It was necessary, therefore, not only to look out for voyageurs, but also for some one capable of performing the duties of an assistant.

The house of the Fur Company, opposite the mouth of Crow Wing River, is the point at which all the agents and clerks who have charge of the various posts on the Upper Mississippi and its tributaries, and as far north as Red and Vermilion Lakes, assemble in the spring, as soon after the opening of the lakes and streams as possible, bringing with them the furs collected during the winter. Each clerk is accompanied by several *engagés* or *voyageurs*, as they are termed, whose business it is to transport the goods and furs between the depot at Crow Wing, and the distant trading-posts, in the fall and spring, and to assist during the winter in the traffic with the Indians. Thus, there is generally a large number of men collected at Crow Wing early in the season. The services of but few of these men are required by the Company during the summer months. They generally spend their time as interest or pleasure may dictate, until the next fall, when they assemble again at Crow Wing, and proceed with their "outfits" to the distant stations for the winter trade.

These voyageurs are almost all "half-breeds," accustomed to yield implicit obedience to their superiors, and to endure great fatigue and privations. They are well acquainted with most of the country within the limits of the Company's operations, and are thoroughly conversant with the management of canoes and the navi-

gation of the interior streams and lakes, together with all the appliances of travel in the Northwest.

On these accounts, we were advised to proceed to Crow Wing, as the most likely place at which to obtain good voyageurs and canoes suitable for the country we were about to traverse. But, before we could reach that place, most of the clerks had come in and made their "returns," and nearly all the voyageurs acquainted with the section of country I was directed to explore, had left the post. My only chance, therefore, was to wait for the arrival of Mr. Chaboeuliez, who, with several men, was daily expected to arrive from Red Lake. Mr. C. had been highly recommended for the situation Mr. Morrison was to have filled, and it was hoped that his arrival would enable the corps to take the field under the most favourable circumstances. He reached Crow Wing on the 13th of June, when he accepted the situation, and engaged to join the corps at Fond du Lac, in July.

On the 15th of June, we completed our arrangements, by the purchase of two half-worn canoes, the best that could be procured; and left Crow Wing at nine o'clock next morning, with four of the best voyageurs in the Northwest, to begin the reconnoissance of the district of country designated in my instructions.

As the country bordering the Mississippi between Crow Wing and Sandy Lake has been partially described by Lieutenant Allen and Mr. H. R. Schoolcraft, and subsequently by M. Nicollet, a very brief outline will be given of this part of our journey.

Between Crow Wing and Rabbit River, the general features of the country differ very little from those of the region immediately around Crow Wing, except that the soil on the general level appears to be thinner and more sandy, and bears a thick growth of small pine. There is also less prairie to be seen from the river.

Eleven miles above Crow Wing, where we encamped on the 16th, I made an excursion of several miles into the country, and found the forest, over much of the tract traversed, destroyed by fire. Most of the trees had fallen to the ground, and in the course of two or three years, if the annual fires are kept up, the whole tract will be prairie, and not a vestige of the forest which once occupied it will remain. A succession of fires are required to kill the trees, but after that is done, succeeding fires and the wind soon bring them to the ground, and they disappear in a short time. From facts which have come under my observation in several parts of the territory, I am led to believe, that if, after the clearing of the pine forests, the annual fires cease, a growth of oak springs up in some places, and aspen in others.

Up to Rabbit River there is but little bottom land. The bottoms which occur are rich, and support an excellent growth of oak, bass-wood, elm, aspen, and some soft maple, but most of them are narrow and subject to overflow during high freshets.

About four miles above the mouth of Rabbit River, good second-rate pine occurs on the ridges on both sides of the Mississippi. The river bottoms also begin to widen, and in addition to the timber just named, butternut, ash, and birch are common. Two miles further up, White Bearskin River comes in from the west. The shores of this stream, as well as those of the lake from which it flows, are represented as being covered with first-rate pine. The pinery of which this forms a part, extends beyond Pine River, which enters the Mississippi from the west,

about forty-six miles above Crow Wing, and is the largest stream in that distance. It is navigable for canoes three days' journey.

About eight miles above Pine River, Rabbit Portage begins. It is about three hundred yards long, and leads over a ridge of drift, to Rabbit Lake, a large sheet of water, which discharges through four smaller lakes and Rabbit River, into the Mississippi twenty-four miles below. The distance from the portage to the mouth of Rabbit River, is eight miles, and the Indians, who travel in small canoes, are accustomed to take this route, especially when going north, as sixteen miles travel up stream is thus saved. There is also a portage from this lake to Red Cedar Lake, a distance of six miles, over tolerably good ground. East of Rabbit Lake, maple ridges begin, and, with alternations of swamp and meadow-land, extend to the cluster of small lakes northwest of Mille Lacs.

Three or four miles beyond Rabbit Portage the river bottoms become wider, and are densely wooded. The trees, among which are many good pines, are large, and, with the exuberant undergrowth, indicate a rich soil. These bottoms lie from six to eight feet above the present level of the river, and are occasionally intersected by ridges of drift, from ten to fifteen feet high, and covered with small birch and aspen. As you ascend, the bottoms gradually become lower, until, two miles below Red Cedar River, the Mississippi is bordered for some distance, on the east side, by low meadows. The last good pine was seen about ten miles above Rabbit Portage, while the soft maple grew more abundant than at any point lower down.

The day before leaving Crow Wing, a large caterpillar, resembling the "army worm" somewhat, appeared there in considerable numbers, and, as we ascended the river, became more and more abundant. When we reached the bottom lands just described, we found the forest so completely stripped of foliage by this insect, as to give to the landscape more the aspect of winter than of summer. They appeared to spare no trees, except the pine and butternut.

Above the mouth of Pine River, the Mississippi is exceedingly crooked. According to the best estimate I could make, the distance by water from the mouth of Pine River to Red Cedar River, is twenty-five miles, while, in a direct line, according to the statements of voyageurs who know the country well, the distance is not over ten miles. Above the Red Cedar, up to the outlet of Sandy Lake, its course is still more tortuous. Across many of the bends the Indians have established regular portages, in ascending the river with loaded canoes, most of which may be passed over in from three to five minutes, while from three-quarters of an hour to an hour is required for a canoe to pass up by the river.

About thirteen miles above the mouth of Red Cedar, Mud River comes in from the east. This river heads in the vicinity of Mille Lacs, and is the route usually pursued in summer by the Indians, in passing from Sandy Lake, and places still further north, to Mille Lacs. In winter, when the lakes and swamps are frozen, the route between the two lakes leads in a direct line south from Sandy Lake.

Between the mouth of Mud River, and that of Big Willow River, the Mississippi winds through wide alluvial bottoms, covered with a dense forest of oak, elm, ash, hard and soft maples, white and red birch, and linden, with a few small pines and balsam firs at one or two points. About ten miles above the mouth of Big Willow,

drift banks, from twelve to fifteen feet high, and covered with scrub pine, approach the river on the west side, and continue for nine or ten miles. From this point to the outlet of Sandy Lake, the river bottoms are, in all respects, like those just described.

We entered the outlet of Sandy Lake on the morning of the 22d of June, at half-past eight o'clock, and pitched our tents on the island nearest to, and immediately opposite, the Indian village.

Between Crow Wing and Sandy Lake, there is no rock visible *in place* on the Mississippi. The sections exposed by the river, throughout the whole distance, present deposits of clays, sands, pebbles, boulders, and loam; varying in thickness from ten to one hundred and twenty feet. Such deposits are usually described as a part of the drift formation, although it is evident, to my mind, that they were deposited under very different circumstances from those which operated during the great "*erratic*" period.

In some places the drift-hills are conical, or, rather, domelike; but, most generally, the elevations are in the shape of narrow, oblong ridges, with gently undulating valleys between them, and, occasionally, wet meadows, bogs, and small ponds.

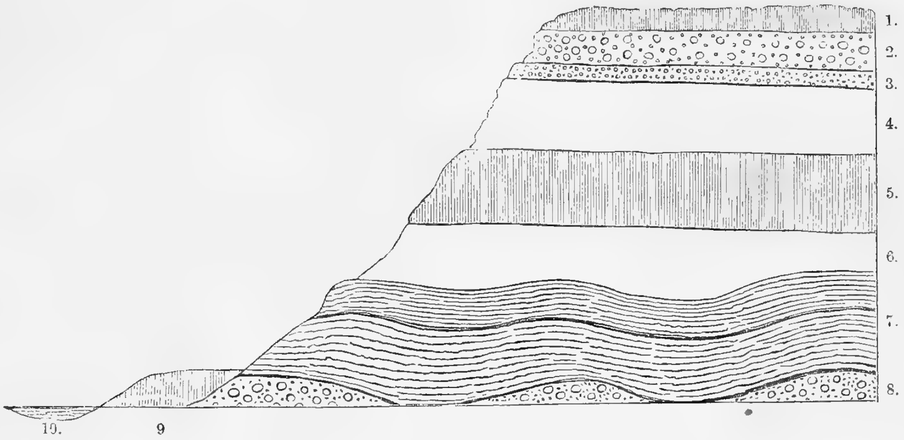
The lowest member of this formation exposed on the Mississippi, is a stiff, tenacious, blue clay, containing numerous small siliceous pebbles and gravel-stones, derived principally from calcareous rocks. It effervesces strongly with acids. The upper part of this clay is, in many places, red, and the numerous small springs which discharge at its junction with the sand-beds above, are highly charged with iron. The thickness of the clay varies from four to thirteen feet, though its total thickness could not be determined with accuracy, as the beds are only elevated above the water for short distances, and at long intervals, sufficiently high to show the base upon which they rest, which is a boulder deposit, embedded in sand and gravel. At the points where these boulders are elevated, they form slight rapids, varying from fifty yards to half a mile in length. The clay-beds are often thinly laminated, and, at some exposures, the laminæ are wrinkled. They conform in their dip to the general undulations of the country. In some places, the upper part of the clay-beds have thin seams of sand running through them.

The clays are overlaid by a deposit of coarse sand, distinctly bedded, and consisting principally of quartz grains, mostly rounded, but many of them angular. Quite a large percentage of the sand appears to have been derived from trappous rocks, and is in the form of irregularly-rounded greenish grains, generally smaller than the siliceous particles.

The lower sand-beds are generally yellow, sometimes of a dark reddish-brown colour, and frequently contain crusts cemented by oxide of iron. The upper ones are lighter-coloured, and, near the surface, present a pale yellow appearance. Not unfrequently, the upper beds contain stripes of dark yellow and red sand, and occasionally exhibit lines of oblique lamination.

Above the beds just described is a bed of sand, from three to six feet thick, filled with rounded pebbles and small boulders, derived from granitic and metamorphic rocks; and overlying the whole is a deposit, of variable thickness, of sand and loam, and soil.

The annexed diagram represents the succession of the different members of the deposits on this part of the Mississippi.



1. Soil. 2. Small boulders and pebbles. 3. Pebble-bed. 4. Light-coloured fine sand. 5. Dark yellow sand, sometimes banded with red stripes. 6. Coarse red sand, often highly ferruginous. 7. Beds of red and blue clays. 8. Deposit of large boulders. 9. Alluvion. 10. Bed of the river.

At the point on which the old Trading-House of Mr. Aitkin stood, at the junction of the outlet of Sandy Lake with the Mississippi, the drift-hills are about sixty feet high, and show numerous boulders of quartzite, felspathic granite, syenite, greenstone, and hornblende slate, with some large pebbles of red sandstone.

The width of the Mississippi River, between Crow Wing and Sandy Lake, varies from ninety to one hundred and sixty yards. At the mouth of Sandy Lake River, it is a little over one hundred yards wide. The distance between the two points, following the meanders of the river, according to my estimate, is one hundred and forty-one miles. The outlet of Sandy Lake, at its junction with the Mississippi, is about forty yards wide, and is nearly a mile and a half in length, with very little current. The waters of the lake are said to rise and fall with the river.

The neighbouring soil is a sandy loam, and produces good corn, potatoes, and turnips, together with the generality of garden vegetables. As you recede from the lake, north and south, the soil becomes poorer, the country presenting a succession of drift ridges, covered with small birch and aspen. Some few ridges in the vicinity of small lakes, in both directions, bear hard maple. Between this place and Mille Lacs, the country is represented as being made up of these ridges, bearing a dwarfish growth of timber, with intervening swamps, but no prairie.

Sandy Lake is very irregular in outline, and is about six miles across in its long diameter. It contains several small islands, upon one of which we encamped; and at this place, as before mentioned, the observations for geographical purposes were made by Colonel Whittlesey.

The caterpillar before noticed, and which appeared at Crow Wing on the 15th of June, was very abundant here, where it was first seen on the 19th. The trees, bushes, and shrubs, were literally covered with them. The Indians said this was its first visit to this section of country, although I was told, by one of my voyageurs,

that he saw a few of the same kind on St. Louis River, about forty miles distant, the year before.

At this place we were indebted to the Rev. Mr. Spates, who has charge of the Mission, for a kind reception, and some valuable information.

From the outlet of Sandy Lake to the mouth of Crow Wing River, the course of the Mississippi is southwest, the valley through which it runs in that distance being parallel to the valley of the St. Croix River from the mouth of Snake River to Pijiki Lake; and a line drawn northeast from Sandy Lake would cross St. Louis River, after following the course of West Savannah River, and would enter the valley of Big Whiteface River, and follow it to the sources of that stream. The parallelism of these valleys will be noticed again.

2. *From Sandy Lake to Fond du Lac.*—On the 24th of June, we left Sandy Lake for Lake Superior, by the route over which the Fur Companies have transported their goods toward the far northwestern posts for many years past.

Prairie River, one of the largest tributaries of Sandy Lake, is about twenty-five yards wide at its mouth, and enters the lake between drift-hills sixty-nine feet in height, and covered with small pine, aspen, and birch. In winter, and occasionally in summer, the Indians, passing from Sandy Lake to Fond du Lac, follow this river to its source, and then, by a portage of twelve miles, reach St. Louis River, a few miles below the mouth of East Savannah River. The distance to Fond du Lac by this route is considerably less than by the Savannah Rivers. In summer, however, the swamps about the head of Prairie River are almost impassable, and then the line of travel is the same as the one pursued by us.

West Savannah River enters Prairie River about a mile and a half above Sandy Lake. It is twenty feet wide at its mouth, but soon contracts to ten or twelve feet, which general width it retains throughout its course. It is extremely crooked, and winds through extensive swamps covered with aquatic grasses. It is very shallow, becomes rapid towards its source, with a pebbly bottom, and, as the portage is approached, is obstructed by boulders.

Toward the head of the stream, the swamps through which it flows are surrounded by high drift-hills, on the sides and tops of which are many enormous boulders, derived principally from granitic, gneissoid, and schistose rocks. Among these hills, the stream expands into small ponds, connected by a mere rivulet, barely wide enough to let a canoe pass. On the summit of a high hill, immediately south of the first pond, is a boulder of syenite, sixty-eight feet in circumference. It is circular, flat on the top, and exposed above ground three and a half feet.

The distance from the mouth of the river to the beginning of the portage, is about ten miles. The portage is six miles long, and leads over the highlands which divide the waters of the Mississippi from those of Lake Superior. The dividing ridge is composed of ranges of drift-hills, the highest of which, on the portage, is, by barometrical measurement, one hundred and thirty-nine feet above the level of Sandy Lake. The observations were made at the end of the fourth "pause," one hundred paces northeast of a small pond. These hills in their prolongation appear to have a general bearing transverse to that of the great ranges of crystalline, meta-

morphic, and trap rocks, which lie south and east of this place. Among the boulders which cover the summit-level, are a great many large ones of gneiss.

For the first four and a half miles, the portage is dry, and passes over ridges covered with young birch, maple, and pine. On some of the ridges, the pine may be considered first-rate. The east end of the portage, for the distance of a mile and a half, runs through a tamerack swamp, which was flooded with water, and next to impassable. It is generally considered the worst "carrying place" in the North-west, and, judging from the great number of canoes which lie decaying along this part of it, having been abandoned in consequence of the difficulty experienced in getting them over, its reputation is well deserved.

East Savannah River, where the portage strikes it, is about five yards wide. It comes from the northwest, and turning a short distance below the portage, pursues a general northeasterly direction to its junction with St. Louis River.

Soon after leaving the portage, the river increases in width to one hundred and fifty or two hundred yards, and is thickly grown up with rushes, except about the centre, where there is a channel fifteen or twenty feet wide, without obstruction.

Some of the low ground bordering the river is wet prairie, with a good growth of grass, but most of it, for the distance of fifteen miles (following the course of the stream), east of the summit-level, is a bog, with low, narrow ridges and knolls rising out of it like islands, and covered with a diminutive growth of tamerack, aspen, and birch.

About thirteen miles below the portage, the banks of the river are composed of sand and gravel, and three miles further, a red clay-bed appears above the water, and gradually increases in thickness to fifteen feet, overlaid by twenty-five feet of sand and marl. Where the clay-banks come up to the water, frequent slides occur, by which the upper beds, of less tenacious material, are precipitated into the stream, carrying with them their growth of trees, which collect in the bends and narrow parts, and form "rafts."

The clay in the lowest exposed portion of the beds is in thin layers, from an eighth of an inch to an inch thick, and is extremely indurated. Where the slides occur, many large boulders are exposed in the upper part of the deposits, derived from the same rocks as those seen on the dividing ridge.

The country between the boggy lands and St. Louis River, is timbered principally with aspen, maple, ash, elm, birch, hemlock, pine, and fir.

On the morning of the 26th, we reached St. Louis River, and hastened to Fond du Lac, at which place we arrived on the 28th. The distance between Sandy Lake and the Trading-Post, by way of the Savannah Rivers, is, according to my estimate, ninety-six miles.

The day after our arrival at Fond du Lac, I sent two men, with a canoe, to La Pointe, to procure supplies sufficient to last during the progress of the reconnoissance of the north shore of Lake Superior. During the absence of these men, Colonel Whittlesey was to remain at the Trading-Post, for the purpose of making astronomical observations; or, in case the weather should prove unfavourable for such purposes, to investigate the geology of the range of hills north of the village; while I proceeded to examine Left-hand and Black Rivers, the latter of which is crossed

by a trap range, in which some veins of copper ore had been discovered, and an attempt made to work them. On the 30th of June, I started, with two voyageurs, and descended the St. Louis to Fond du Lac Supérieure.

3. *Left-hand and Black Rivers.*—On the morning of the 1st of July, I started up Left-hand River, and at half-past five o'clock, in the afternoon, reached the mouth of Black River, a distance of twenty-five miles by the windings of the stream.

Ne-muj-i-ti-gué-ag, or Left-hand River, as far as exploration was made (ten miles above the mouth of Black River), is from twenty to thirty yards wide, and from three to ten feet deep. It is almost entirely free from driftwood; and, except a few inconsiderable ones (which are easily ascended by canoes), unobstructed by rapids. Between its mouth and the mouth of Black River, neither rocks nor pebbles are visible, except at three points, where there are small collections of angular fragments of trap and metamorphosed rocks. The water is of a reddish-yellow colour, and after heavy rains discolours the waters of St. Louis River above its mouth, and the waters of the Lake, for some distance beyond the "Entry," as the mouth of St. Louis River is called.

Its banks are from three to ten feet high, abrupt, and covered with timber. They consist of sandy alluvion and red marl, resting on a bright red, ferruginous clay, with a seam of blue clay intervening. At one of the points referred to as exhibiting fragments of rock, there is, apparently, a slight axis of upheaval, the clays being bent upward, as shown in the annexed diagram, and baked sufficiently hard to withstand the action of water, and form a rapid. The lower part of the clay-bed contains small pebbles.

1. Alluvion.
2, 3. Red marl.
4, 5. Blue clays.
6. Red clays.

Between this river and St. Louis River, the country is alluvial, and presents the appearance common to the bottom lands of all the streams between the south shore of Lake Superior and the dividing ridge. It is heavily timbered, and for the first six or seven miles above the mouth of Left-hand River, bears a great deal of large white cedar, large "canoe" birch, poplar, and fir. About five miles further up, there is a good growth of maple, ash, and elm, with spruce on the hills. On the right side of the river, the country is rolling, and so continues up to the trap ridges, becoming more broken as they are approached.

About thirteen miles above the mouth, I passed the track of one of those violent hurricanes which occasionally occur in that region. Its direction was from south to north, and its path about three hundred yards wide. Almost every tree in its course was twisted off, from ten to fifteen feet above the ground; and many of the large trees on the margin were torn up by the roots, their tops being inclined toward the centre, while most of those not uprooted were bent in the same direction.

Me-kud-á-sibi, or Black River, is a small stream, emptying into Left-hand River from the southeast. Its waters present a striking contrast to those of Left-hand River. They are entirely free from sediment, and so limpid, that in the shadows of the hills and trees they appear perfectly black. The stream is too much obstructed by drift-wood near its mouth, and too shallow higher up, to be navigable for canoes. I therefore pitched my tent near its mouth, and proceeded to explore it on foot. About eight miles above the mouth, following the windings of the river, red sandstone shows itself, in place, at the water-level. It is in thin layers, from an inch and a half to eight inches thick, banded with red and grayish stripes, and dips northwest at an angle of 14°. (*See Section from the Valley of St. Croix R. to Rainy Lake,* Pl. 2, N., Sec. 2.) The intervening country is hilly; the general bearing of the ridges being northeast and southwest, with occasional spurs bearing easterly and westerly, and north and south. The deposits in this distance are:—

1. Alluvion;
2. Red marl, with boulders;
3. Red clay;

overlying a deposit of red and drab-coloured sandstones.

The upper beds of the sandstone are buff-coloured; made up of rounded grains of quartz, well cemented; rather coarse-grained; compact; and when exposed to the influence of the atmosphere for some time, acquire a reddish tint externally. The lower beds are of a beautiful maroon-colour, with irregular grayish bands and points; fine-grained, with an occasional coarse grain; tolerably coherent; and marked with fine parallel lines of deposition.

The rock rapidly thickens to forty feet, overlaid by heavy clay and marl beds, and continues to increase in thickness up to the metamorphosed and trap rocks. As these last-named rocks are approached, the sandstone acquires a dark reddish-gray colour, is thicker bedded, harder, better cemented, weathers well, and would make an excellent building-stone. Beneath these beds it becomes thin and shaly, and contains small gravel, and is, finally, intercalated with beds of conglomerate.

The sandstone is underlaid by a coarse conglomerate, which, at a distance from the trappous rocks, is loosely cemented, and weathers easily. It is made up of red sandstone, quartz, jasper, and clay-slate pebbles, most of them rounded, and many of the quartz pebbles polished. By far the greater portion of the pebbles, however, are derived from the red sand-rock. Those from the slate have assumed the prevailing red colour. Some of the quartz pebbles are from three to four inches in diameter.

Where the sandstone and conglomerate approach the trappous rocks, they are altered both in texture and colour. The sand-rock acquires a dark brown colour, and is converted into a true quartzite, exceedingly hard and compact; while the siliceo-argillaceous cement of the conglomerate is similarly affected, but without becoming more firmly united with the contained pebbles. Nos. 483 to 487, show the degrees of change produced by the intrusion of the trap dikes.

Below the conglomerate, an altered argillaceous slate comes in, so completely

metamorphosed, however, by the trap dikes which traverse it, that it assumes a trappous and amygdaloidal character, differing but little from the trap with which it is in contact. The slate is dark-coloured, almost black, compact, and often crystalline in its structure.

From the lower conglomerate beds to the main greenstone dike, the distance is about two hundred and fifty yards; and in this space the disturbance of the sedimentary rocks is very great, the strata being broken up and mingled in the greatest confusion; the sandstone, conglomerate, and slate being thrown into a nearly vertical position, and traversed by narrow dikes of trap, or bedded intercalations. Between these dikes or beds the sandstones and shales are converted into a reddish-coloured, amygdaloidal, trappous-looking rock, containing thin seams of copper ore. The ore is also disseminated, to some extent, through the rocks. These metamorphosed rocks also contain narrow seams of red clay, and strings and nodules of a soft, greenish, magnesian mineral, found abundantly among the volcanic grits of the north shore of Lake Superior, described by Dr. Owen under the name of *Thalite.* These metamorphosed rocks also contain epidote, and are traversed by seams of jasper.

The dike of greenstone at the Falls bears northeast by east and southwest by south. Over this dike the water falls, in three cascades, one hundred and forty-four feet, through a narrow, winding gorge, with perpendicular walls of rock on each side. The whole fall, including the rapids above the dike, is one hundred and forty-nine feet. At the point from which the first leap is taken, the channel is not over six feet wide. The top of the ridge, on which Plummer's cabins stand, is one hundred and sixty-six feet above the river-bed at the bottom of the Falls, and commands an extensive view in the direction of Fond du Lac, and as far as the culmination of the "Grand Portage" of St. Louis River.

Twenty-five feet above the Falls, No. 491 comes in, and, for the distance of two miles above, by the meanders of the river, there are exposures of altered slates, intercalated with beds of trap, and traversed by dikes of greenstone, as seen in the river-bed; when amygdaloid again occurs, a short distance above the "Upper Falls." At this point, the water falls over altered slate, at its junction with the amygdaloid below. The river is about forty feet wide, and falls perpendicularly, thirty feet, into a circular basin about sixty feet in diameter. A large mass of rock on the brink of the precipice, midway the river, divides the water into two chutes, and adds greatly to the picturesque appearance of the fall. A vein of copper ore is said to have been discovered near the fall, and a small cabin has been erected near by, for the purpose of securing the "location."

A short distance above this, the stream is crossed by a dike of greenstone; and a little further up the river is a rapid, made by the uptilted edges of altered slate. This is the last rock exposed on the river, so far as exploration was made, which was for the distance of three miles above this point. Between the two falls, the metamorphosed rocks lying between the trap dikes have a general dip to the southeast by south, at an angle varying from 51° to 54°. The exploration of this range ceased at a point about three miles west of Mashkegwagoma Lake, which is the source of Aminekan or Spawn River.

It will be seen, from this account of the geology of Black River, that it consists, like that of all this section of country south of Lake Superior and north of the water-shed, of a succession of beds of marl, drift, sands and clays, red and variegated sandstone, conglomerates, shales and slates, with, probably, bedded traps; and all traversed by trap dikes,—the main ones, of greenstone, having a northeasterly and southwesterly bearing, and, in common with the sedimentary rocks, intersected by narrow dikes of basaltic-looking trap, bearing a few degrees east and west of north and south.

All the lower members of the sandstone series found in Wisconsin and Minnesota occur on this river, although no one of them is developed to the same extent that they are at other localities. The sandstone does not differ in any respect from that seen along the south shore of Lake Superior, between Fond du Lac and Montreal River; at the Apostle Islands; on the waters of Bad River; at Lake Gras; on the St. Croix, Snake, and Kettle Rivers; and on St. Louis River, above Fond du Lac Village. The lower beds are also similar in character to the red sandstones found by Dr. Shumard on St. Peter's River, resting on crystalline rocks. While the predominant colour is red, strata of gray, yellow, and dark brown rock are of frequent occurrence; and many of the beds are variegated with green, gray, yellow, and dark-coloured bands and spots. This is also the character of some of the beds on Wisconsin River, south of Whitney's Rapids.

The upper layers decompose, almost universally, with great facility; while, lower down, they become more compact and close-grained, are better cemented, and would, in many places, afford a durable building rock. This is especially the case in the vicinity of trap dikes.

Except near intrusions of trap, the sandstone shows no evidence of violent disturbance; and in some instances the eruption of the trap has taken place without any signs of the violence which is generally considered a necessary attendant on such phenomena, being discoverable in beds in the near vicinity of dikes, the strata remaining unbroken almost up to the intrusive rock, and the dip appearing more like the result of gradual elevation, or of deposition on an inclined plane, than of sudden and violent upheaval. Again, however, the sedimentary rocks have been dislocated with great violence, and the broken beds lie confusedly at all angles, up to a vertical position. This is especially the case where there appears to have been first a series of lateral intrusions, proceeding from a main dike, injected between the sedimentary strata, and afterwards the whole subjected to another convulsion, sufficient to produce a complete overthrow of the intercalated trappous and sedimentary beds, as seems to have been the case at the Falls of Black River.

Ripple-marks, so common in some of the beds on St. Louis River and along the Lake coast in the neighbourhood of Pointe Detour, and at various other places, were not noticed in the sandstones of Black River.

The Black River conglomerate resembles in composition and colour that met with near the mouth of Montreal River, and on the portage between Long Lake and Alder Creek, as well as that which occurs near the mouth of Snake River, on the St. Croix, above the mouth of Kettle River, between Pine Rapids and Nema-

keveagon Lake, and at various other points on that stream, and also that of the Bois Brulé River. It differs from that exposed on St. Louis River, which is made up principally of quartz pebbles, in being composed of materials derived in greatest proportion from the rocks with which it is immediately associated, and in conforming to the general colour of the formation.

The trap rocks which cross Black River belong to the range which, continued in a northeasterly direction, crosses the Aminekan, and other neighbouring tributaries of the Lake, and which, at several localities, has been found to contain copper ores.

At the Falls of Black River, copper ores were discovered several years since; and a mining company took possession of the "locality," for the purpose of "proving" them. After expending several thousand dollars in opening the "veins" and raising ore, the works were abandoned in 1848. The ores occur at this place at the junction of the amygdaloid with the greenstone trap, and also at the junction of the amygdaloid with altered shales and sand-rock. (See Nos. 482–488.) They occur in thin seams, which have a nearly north and south direction, and which can hardly be called veins. They are also disseminated to a considerable extent through the metamorphosed sedimentary beds, where they come in contact with the trap rocks. Two of the ores from this place yielded, on analysis, 10 and 11 per cent. of copper respectively.

In another part of this range, about a mile and a half from the Falls, on a small tributary of Black River, the La Pointe Company have a "location," on which they have expended a large sum of money, in sinking shafts and proving the mine. Three shafts have been sunk on the vein, which has a course north 30° east, and south 30° west. At the time I visited the place, the shafts were filled with water, so that I had no opportunity for investigating the character of the vein further than surface indications would afford. Its character, in an economical point of view, however, may be determined from the fact, that the Company, after a fair trial, were forced to abandon it as unproductive. It is twenty-one feet wide, contains a great deal of epidote, and hades east 51°.

No. 492 cccurs on a small stream near Russell's old house, and in near proximity to the vein, which crosses at that point. The rock dips to the northwest at an angle of 37°.

On the morning of the 6th of July, I proceeded to Fond du Lac Village, where I found Colonel Whittlesey, who had just returned from an excursion to the range north of the trading-post; and also the men who had been sent to La Pointe for provisions. The next day was occupied in making preparations for a reconnoissance of the north shore of Lake Superior, as far as Two Island River.

On the 8th of July, we left Fond du Lac Village, accompanied by Mr. R. B. Carlton, in the capacity of assistant. We were detained at the Entry by high head winds until the afternoon of the 10th, and did not reach Two Island River until the 13th. The plan of proceeding directly to the most distant point for the commencement of our examinations, afforded us an opportunity of glancing at the rock formations as they are developed along the Lake shore, and thereby acquiring some general knowledge with respect to their character; and the information thus gained was afterwards found to be of the most essential service. The results of this

reconnoissance will be given in another Section. It was finished on the 30th of July; and on the 31st, I proceeded to La Pointe, to procure provisions for the remainder of the season. During my absence, Colonel Whittlesey explored Aminekan and Poplar Rivers. I reached St. Louis River on the 9th, and on the 12th we began our explorations on that stream.

4. *St. Louis River, from Fond du Lac to the Mouth of Upper Embarras River.*—A short distance above the village of Fond du Lac, an exposure of sandstone, ten feet in thickness, is seen on the left bank of the river, overlaid by a very heavy deposit of sand, clay, and red marl. The upper beds are thick and compact, the lower ones shaly, and contain numerous small pebbles at the partings. As the river is ascended, the rocks rapidly increase to sixty-five feet in thickness, and dip to the southeast 7°. Nearly three miles above the village, following the bends of the river, the sandstone is found to rest on conglomerate, and this last-named rock on shales and slates. The deposits up to this point, in descending order, are:

1. Red sandy marl.
2. Red clay-beds—stratified and indurated, with boulders in the upper part, and dipping with the sandstones.
3. Gray sandstone, alternating with white, red, and mottled beds, in layers from one to three feet thick.
4. Shaly sandstone, with hard seams.
5. Very light gray sandstone, of a reddish tint, with numerous casts of shrinkage cracks on the under surface of one of the beds, and covered with scales of mica. (No. 438.)
6. Dark reddish-brown shale, with alternations of thin beds of hard, argillaceous sandstone, which exhibit on the upper surface numerous rounded elongated eminences, which have sometimes been called "mud drops." (Nos. 443 and 444.)
7. Light reddish-gray sandstones and shales. (No. 445.)
8. Thin beds of siliceous shale and pebbly sandstone, alternating with dark red, ripple-marked beds. (No. 446.)
9. Siliceous shale, with seams of small pebbles. (No. 447.)
10. Fine conglomerate. (No. 442.)
11. Red shaly sandstone—like No. 447.
12. Greenish-gray sandy schist.
13. Coarse quartzose conglomerate. (No. 441.)

The dip of the sandstones and siliceous shales, and the upper conglomerate (No. 442), is to the southeast, at an angle varying from 6° to 7°. About half a mile above the junction of the overlying beds with the coarse conglomerate (No. 441), is an exceedingly interesting point, the conglomerate being suddenly elevated at an angle of 18°, and exposing the lower shales and slates, upon which the upper rocks rest unconformably. At this place is exposed, in one view, the junction of the slates with the conglomerate, together with the overlying siliceous shale, fine-grained conglomerate, and sandstone beds. (See "*Section from the mouth of Upper Pinnette River to Rainy Lake,*" on Pl. 2, N.) The most elevated point of the arch of uplift, which bends regularly to the water on each side of the axis, is twenty-five feet above the water-level, the arc or span being about four hundred yards. At one point, the conglomerate fills a fissure, with vertical walls, and several feet in width, in the overlying siliceous shale, and appears to have been thrust up from below like

a dike, the rent having been produced, probably, at the time of the upheaval and bending of the strata.

About half a mile above the first exposure, in the bed of the river, of the lower conglomerate, it is underlaid by No. 448, which has an east and west bearing, and dips to the north at an angle varying from 26° to 51°. It measures forty feet in width across the line of strike. Next to this rock lies No. 449. Its colour is probably owing to the presence of chlorite. It is sufficiently soft to be worked with a knife, and is occasionally used for pipestone by the Indians, though it differs materially from the red argillite employed by the Sioux for that purpose. It bears east and west, and dips to the north at an angle of 74°. In consequence of the undulations of this rock, and the overlying beds, which sometimes conceal it, as well as the variableness of the angle of dip, its thickness could not be determined. Its great thickness, however, may be inferred from the fact, that in conjunction with No. 448, it is exposed in the river-bed for the distance of nearly half a mile, and always dipping at a high angle. It resembles very much No. 23, brought from Flint Lake.

About a quarter of a mile above the last exposure of the conglomerate (No. 441), the shales disappear, and red clay, marls, and drift, make the river-banks until the first or Lower Falls are reached. At this place, No. 450 is exposed, bearing east and west, and dipping south at an angle varying from 80° to 88°. It is traversed by veins of No. 452, from two to ten inches wide, having an east and west direction. This last rock alternates with beds of No. 451, and contains small, irregular cavities, filled with iron pyrites and calcareous spar.

Proceeding in the direction of the upper end of Grand Portage, these slates take on the character of No. 453; and still further up the river, bear a great resemblance to some of the altered slates found on Mud Lake. Some of the beds are highly altered, and indicate the near vicinity of intrusive igneous rocks, although no such beds or dikes of trap were discovered among them as occur at numerous other localities in the same range. Near the upper end of Grand Portage, the argillaceous slates bear east 11° north, and west 11° south, and dip east of south. At one point, the beds are nearly vertical for some distance, and the dip is reversed.

On "Six Pause Creek," about three miles distant, in an east by south direction, the slates bear northeast and southwest, and appear to have been altered by intrusive trap; and on a small creek about three miles south of this place, another exposure was found near the summit-level of the portage, bearing east and west, and dipping to the north at an angle of 40°.

Between Grand Portage and Knife Portage, the blue argillaceous slates continue to show themselves in the river-banks, and also in small islands, rising from ten to twenty feet above the water.

It will be perceived from these details, that after leaving the exposure of conglomerate (No. 441), the only rocks seen in place were argillaceous and magnesian slates; although it is highly probable that they are traversed by trap rocks in that distance. I am led to this conclusion from the high angle at which they dip in several directions, the changes of bearing, the evident alteration produced in some of the beds by igneous action, and the fact that trap rocks were found associated

with them a short distance higher up the river, as well as in every other part of the District explored.

Between Fond du Lac and Knife Portage, the river is obstructed by numerous rapids, four of which merit the name of falls. About three miles above the village of Fond du Lac, the portage trail begins, and over it everything has to be carried in ascending or descending the river. By great exertions, experienced voyageurs may ascend with light canoes nearly to the foot of the Lower Falls, but beyond that point they cannot pass in any stage of water.

The Lower Falls are a series of cascades, ten or eleven in number, and from six to ten feet in height, running obliquely across the stream, and extending for the distance of half a mile. The water falls in this distance, including the rapids immediately above and below the upper and lower cascades, one hundred and three feet. At no one point, however, does the water fall more than ten feet, and then glides, rather than falls, down the inclined layers of slate.

The Second Falls are about a mile and a half above the first; and while the descent from top to bottom is not nearly so great, they present a much more imposing appearance than the lower ones. Enormous walls of rock, from thirty to forty feet in height, project from either bank, and run nearly across the river, like huge dams. At one point, the channel through which the water flows, is forty feet in width, and at another dam, it was found to be only twenty-five feet wide, the width of the river above and below being from one hundred and fifty to two hundred yards. During the floods which sometimes occur in this region, there is, no doubt, a perpendicular fall of water at this place of over forty feet; that the river flows over the dams at such times, being abundantly proved by the drift-wood lodged on their tops. At present, however, there is a fall nearly perpendicular, at one point, of fifteen feet in height and twenty in width, and this is the only place at which anything like a perpendicular fall was observed on the whole river. The height of these falls, including the upper and lower rapids, is nearly seventy-six feet.

The Third Falls, like the others, are made up of a series of cascades, and for grandeur and beauty, equal any scenery of the kind I have met with south or west of Lake Superior. Although the fall, including the rapids, is only forty-five feet, the disposition of the rocks, and the surrounding scenery, combine to render the effect indescribably beautiful.

The Fourth Falls are made up of a series of five large cascades, and numerous smaller ones. The ledges of slate cross the river nearly at right angles, and are cut through, as at the Second Falls, into deep narrow chutes, sufficiently wide, however, to afford a passage for the waters, except during freshets, when they flow over the highest barriers. The whole height of the fall is a little over one hundred feet.

The descent from this point to Lake Superior, including all the falls and intermediate rapids, is three hundred and eighty-nine feet.

Knife Portage is about a mile and three-quarters long, and is so called from passing over the sharp edges of uptilted slates. Near the lower end, the rock is similar to that found at the lower falls; and rather less than half a mile further up the river it is traversed by a trap dike. Above the trap, the slate is highly metamorphosed, and in consequence of the disturbance produced by the intrusive rock, is

tilted for some distance at a high angle, producing a succession of small cascades, over which the water falls altogether about twenty feet. Above these metamorphosed slates, and as far as the fall at the upper end of the portage, bluish-coloured clay slates, like No. 453, make the river-bed, and are exposed at numerous points in the country around.

From the lower end of the portage to beyond the cascades, the rocks bear east and west; near the upper end, the bearing is east-southeast and west-northwest. Except in the immediate vicinity of the trap dike, where the angle was greater, but not measured, the dip does not vary much from 49°, south and south-southwest, for the whole distance, which is nearly or quite a mile in a direct line across the strike.

Just below the termination of the portage, is a nearly perpendicular fall of eight feet, and above this the slates assume a somewhat crystalline character, and at the distance of three quarters of a mile, graduate into hornblende slate. One mile above Knife Portage, by the course of the river, at the second rapids in ascending, the slaty rocks terminate, and the river is crossed by a heavy exposure of No. 454, bearing north by east and south by west. In composition and general appearance, this rock resembles Nos. 613, 625, and 634. This was the last exposure of rock in place seen on St. Louis River.

From the bearing of all the rocks seen between Fond du Lac Village and this place, it is evident that they belong to the same beds exposed on Mission and Kinechigakwag Creeks, and at other points further east and northeast, and which will be described in a subsequent chapter. The beds of traps so constantly found associated with them to the eastward, were not noticed on St. Louis River; still, they may exist there, and have been overlooked in consequence of the frequent concealment of the beds in the river-banks by clay slides, and the long distances between the lower falls and the upper end of Grand Portage, in which the rock can only be seen beneath the water.

As before stated, there are no exposures of rock on St. Louis River from the locality of No. 454 to the mouth of Upper Embarras River. The river-banks show, in almost the whole distance, beds of clay, sand, and drift. At the head of "Long Rapids," the clay-beds are from ten to twelve feet thick, and are overlaid by drift deposits, which rise to the height of forty and sixty feet, a short distance back from the river.

Between fifteen and seventeen miles from Knife Portage, three streams come in,—Cloquet and Esh-ka-bwa-ka Rivers from the east, and Moscossoso River from the west. Between the mouths of the two first-named streams, are some Indian gardens, occupying the first plateau, in which a number of common garden vegetables are cultivated. Beyond this plateau, the country is rolling, and composed of drift-hills and ridges.

Eight or nine miles above the mouth of East Savannah River, Big Whiteface River comes in from the northeast. It is about twenty yards wide at its mouth, and is navigable for canoes up to its source, which is in the neighbourhood of the sources of St. Louis and Cloquet Rivers.

Between Esh-ka-bwa-ka and Swan Rivers, the clay-beds are not seen at many points; the banks, which are from eight to thirty feet high, consisting of beds of

sand and sandy loam, with coarse drift. The soil is very light and poor in most places. Above the mouth of Swan River, the clay-bed, which is exposed for four or five feet above the water-level, is stained of a reddish colour by oxide of iron, and contains a great many pebbles and small fragments of limestone, and also of clay slate. The limestone is drab-coloured and very compact, and in some of the fragments crinoidal remains were found. The clay-beds gradually increase in thickness as you ascend, the prevailing colour being grayish-blue, but often interstratified with red and dark yellow beds. The following section was seen between the mouth of Lower Embarras and Two Rivers:

	Feet.
Sand and soil,	10
Blue clay,	10
Red clay,	5
Blue clay,	10

The clays are stratified, and dip to the southeast at a small angle. They are finely laminated, and often waved. The red bed is highly indurated.

On some of the rocky bars in St. Louis River, many thin slabs of drab-coloured limestone were found, some of them being over two feet in diameter, and containing organic remains of the Silurian epoch. These slabs are so thin and easily broken, that they could not have been transported from any considerable distance unless they had been enclosed in ice.

Up to the mouth of Upper Embarras River, the St. Louis has maintained a width varying from thirty to eighty yards. Above the mouth of East Savannah River, rapids are not frequent, and when they occur are made by accumulations of pebbles and boulders. The hills generally come up to the river on one side, while elm and soft maple bottoms are spread out on the other. Occasionally, both sides of the stream are bordered by bottoms, but I saw no instance in which high banks or hills came up to the river on both sides. The timber for the whole distance consists principally of aspen poplar, fir, spruce, pine, birch, ash, and some hard maple—the growth being small. Above Big Whiteface River, a good deal of cedar was seen on the banks for some distance.

5. *Upper Embarras River.*—We entered this river on the 21st of August, and on the 23d reached Ishquagoma, or "End Lake," as it is termed by the Indians. Between these two points the country consists of a coarse yellow sand, with a very thin soil, supporting whortleberry, mountain-tea, pipsissewa, and a few other plants which flourish in a sandy soil. The trees are all small, and consist of birch, ash, and aspen poplar, with some soft maple in the bottoms, and cypress on the drift-hills. The river is exceedingly crooked, and much obstructed by drift-wood in the lower portion. The banks are generally low, and overhung by the alder, willow, chokeberry, and high-bush cranberry.

Ishquagoma Lake is about three hundred and fifty yards wide in the lower part, shallow, and full of rushes; the upper part is clear, deep, and five hundred yards wide. It is half a mile long, and surrounded by low shores, covered with small

poplar. The Second Lake is reached by a portage two hundred yards long, around a rapid made by boulders, among which I observed granite, syenite, greenstone, and metamorphosed slate. This lake is small and shallow, and the bottom covered with boulders. The stream connecting it with the Third Lake is about thirty yards wide and one hundred yards long. It is filled with boulders, and has a slight rapid in the upper part. Third Lake is a mile and a quarter long, and about four hundred yards wide. It contains several small islands, and many large boulders are strewed around its shores. Fourth Lake is one-third of a mile long, and three hundred yards wide. The portage from this to the Fifth Lake is about two hundred yards in length, over a ridge of boulders; the fall between the two lakes being three or four feet. Fifth Lake is a beautiful sheet of water, and on the west side of it, at the distance, apparently, of two miles, was seen the *Missabé Wachu*, or "Big Man Hills," which form a portion of the dividing highlands between the waters of Hudson's Bay and Lake Superior. A small stream, obstructed by very large boulders, leads to the Sixth Lake, which is a mile and a half long, and from two hundred to three hundred and fifty yards wide. On the west side, the Missabé Wachu approaches within three hundred yards of the lake, and was estimated to be three hundred feet high.

The rock here, which was the first seen, in place, since leaving the vicinity of Knife Portage, is principally syenitic granite, associated with gneiss, and traversed by veins of quartzose granite. (Nos. 493, 494, 495, 496.) The gneiss dips southeast, at an angle of 12°. From the top of this ridge, a number of parallel ridges were seen, bearing to the northeast and northeast by north, some of which appeared to have an altitude nearly double that of the one ascended.

The Seventh Lake, or, as it is called by the Chippewas, *Ininiwishtigonan*, is one mile and a quarter long, and four hundred yards wide, and is embosomed in hills. There is a portage from the upper end, of one mile in length, around rapids. The portage passes over a hill about forty feet high, covered with innumerable boulders, the most of them being granitic. About one mile above the upper end of the portage, we came to the path which leads across the dividing ridge to the waters of Vermilion River.

At this place, which is called by the Indians *Ashawiwisitagon* (and which means, literally, the place from which water runs two ways), we left Embarras River, which was here very wide, without any perceptible current, and bordered by tamerack swamps. We found it necessary to stop on this portage, for the purpose of drying our "outfit," especially the flour, which was in danger of spoiling. We remained three days, partly for the purposes named, and partly on account of hurts received by two of the men, while carrying a large canoe over the portage.

This portage is about five and a half miles long, and has several exposures of rock on it, the most southerly of which is like No. 493 of Embarras River. The highest part of the ridge was estimated to be sixty feet above the river-level. It is covered with large white and yellow pines, and bears east-northeast and west-southwest. (497, 498.) Northeast of this ridge is a lower one, separated from the first by a narrow valley, full of boulders. No. 499 was taken from this ridge. It is traversed by numerous veins of Nos. 500 and 501. About three-fourths the dis-

tance from the beginning of the portage, we passed the culmination. It is made up of porphyritic syenite (No. 503), and ascends gradually from a swamp on the south side to the height of forty feet, and descends, probably fifty feet, in a mile and a half, to Vermilion River.

The portage path is generally good, running over dry pine ridges, but a portion of it is as bad as cedar and cypress swamps can make it. Some of the low ridges are made of very fine drift, and in all the valleys between them swamps are found.

6. *Vermilion River.*—We began to descend this river on the 28th of August. At the point where we embarked, it comes from the southwest, and winds among drift-hills, with swamps intervening. Some of the swamps have small knolls in them, like islands, covered with cypress. The drift-hills have a few pines scattered over them, the other growth being small aspen, poplar, and a few small birch. They are generally from fifteen to twenty feet high, none of them reaching over thirty feet in height.

About six miles below the portage, a tolerably fine-grained, reddish-coloured, syenitic granite, occurs in the bed of the river, forming rapids, around which a portage has to be made over a low granite ridge. (No. 504.) The ridge bears east-northeast, and west-southwest, and as the drift-hills have the same strike, it is probable that they are based on similar ridges. Soon after leaving these rapids, the river bears to the northwest, and soon increases to sixty yards in width, which is increased at one point to one hundred and twenty yards. It is only at the points where rock ranges cross that it is contracted much below sixty yards, and then only for short distances. Throughout the whole distance travelled to-day, below the first rapids, it has scarcely any current, and is bordered by cypress and cedar swamps, no banks being seen at any place except where ridges of rock are met with.

About ten miles below the first rapids, is a low ridge of No. 505, and two miles further, No. 506 is found resting on the gneissoid rock. The junction was not seen. The river here makes a bend, and the same ridge comes to the water again, when No. 507 makes its appearance. About one mile below this, the same rocks are seen again, but whether the beds of the two rocks alternate, as they do in some other portions of the District, I was unable to determine. The hornblendic rock presented occasionally a massive appearance, as it does in the neighbourhood of Flint Lake.

The ridges all cross the river with the same bearing, varying but little from east-northeast and west-southwest. Between the ranges are swamps, in every direction, and along the course of the river they are filled with cypress and tamerack. The current is obstructed by the ridges, which act as dams, giving to the stream very much the appearance of a succession of mill-ponds, connected by short rapids, and illustrates very forcibly the idea advanced with respect to the geology of the country in the Upper St. Croix region, and other portions of the District south of Lake Superior.

About five miles below the point above designated, there is a perpendicular fall of eight feet, over No. 508. The rock bears east and west, and has thin seams of quartz between the laminæ, running in the line of bearing. There are also many

irregular patches of quartz, from eight to ten feet long, and from six to twelve inches wide, which cross the strike nearly at right angles. For a short distance before reaching this fall, the river runs between hills of hornblendic and siliceous rocks, varying from thirty to one hundred feet in height, and having generally a slaty character. The fall of water at this place, including the rapids above and below the perpendicular fall, is sixteen feet. About three quarters of a mile below this, we entered Vermilion Lake.

The first arm of the lake traversed runs east of north, and about four miles from the mouth of the river is an exposure of No. 509. Nearly six miles further down the lake, at the site of the Old Trading-Post, No. 510 is exposed, both on the main shore and on the small islands opposite. We remained encamped at this place two days, for the purpose of affording Colonel Whittlesey an opportunity to determine its geographical position.

The outline of this lake is exceedingly irregular. It presents a succession of deep bays and rocky points running almost to the centre of the lake, and is studded with rock-islands, some of them of considerable size. The long narrow points, deep bays, and numerous indentations, pockets, and islands, render every part of the lake a complete labyrinth, through the numerous winding and tangled channels of which it is no easy matter for a stranger to find his way to a given point. The lake is surrounded by low hills in every direction, and its shores and islands are all densely wooded, there being only one or two small islands which have been laid bare by fires. As you recede from the lake, the country rises gradually, and is timbered with spruce, fir, ash, cedar, maple, aspen, and birch, with pine on the ridges. Birch is scarce and small. In fact, the timber is all small, none being above a medium size, compared with the same kinds at localities further south.

The rocks show themselves at many points in the woods, and are bare for considerable areas, or covered only with a coating of moss easily scraped away by the foot. These rocks, which are eminently magnesian, begin at or near the point where No. 509 was taken. They are thinly laminated, and present at different places various degrees of fineness, from a hard, coarse variety, to a fine-grained stone, almost fine enough for hones. They are traversed by numerous veins of quartz, from an inch to five feet wide, some of which contain beautiful crystals of iron pyrites; and, from some indications noticed, other more valuable minerals will probably be found associated with it. (Nos. 510 and 511.)

The buildings erected here by the "Northwest Fur Company," about thirty-five years ago, have long since disappeared,—nothing remaining of them now, except piles of fallen chimneys, to mark the spot where they stood. The rocky point is bare for a short distance in front of the old building spot, and the rock slopes gradually down into the water. Back of where the houses stood are the remains of a garden, now overgrown with bushes and small saplings. Where the ground is yet open, the Indians have planted potatoes within the last two years.

September 1st. We left the Old Trading-Post at 8h. At 10h. 25m. we got to what appeared to be the lower end of the lake, but could discover no outlet. The remainder of the day was spent in exploring bays, pockets, and channels, but without success; and we encamped about sundown on an island, about three miles,

in a northwest direction, from our last camp. Here the slates resemble No. 509, and are succeeded by No. 512, at the *detroit* connecting the middle with the northwestern portion of the lake. The next rocks, going north, are Nos. 513 and 514, which, with Nos. 515 and 516, lie between Nos. 513 and 517, No. 516 being next the granite. (See Section 2, Pl. 2, N, *from Upper Pinnette River to Rainy Lake.*) No. 517 was the first granite seen in place near the lake. It forms a low ridge, and, judging from the point where it struck the opposite shore, bears northeast and southwest.

September 2d. In little more than an hour after starting this morning, we discovered the outlet of the lake, and again began to descend Vermilion River. There is a rapid about four hundred yards long at the commencement of the river, the water falling in that distance about twenty-five feet. The fall is over mica slate (No. 518), which is traversed by granite veins, some of them very large. The granite is felspathic, the felspar being white, and in large crystals. About a mile below this, rapids again occur, the river falling about ten feet in five hundred and twenty yards. This fall, like the last, is over mica slate, with granite veins traversing it in every direction. The rocks here (No. 519) show a transition from a very fine-grained to a very coarse-grained mica slate, and from the first to a gneissoid rock. The granite veins are either all quartzose or felspathic. One mile and a half below this is another exposure of mica slate, bearing east by north, and dipping to the north-northwest at an angle of 46°. (No. 520.) The rapid at this place falls about six feet; and a short distance below is another rapid, with a fall of five feet, over mica slate. The rock at this place is crossed in every direction by granitic veins from half an inch to ten feet wide; while layers of granite are intercalated with the slate, and conform to the dip and bearing. In some places the slates are fine, in others, coarse; and again, at other points, graduate into gneiss, and the gneiss into granite.

Soon after passing the last-named rapids, the river spreads out into a lake, about a mile and a quarter long, and from three hundred to three hundred and fifty yards wide, with no perceptible current. At the lower end of this lake, a narrow channel, sixty or seventy feet wide, conducts around a granite ridge (No. 521) into another lake. In about four and a half miles, this lake narrows to one hundred and seventy-five yards in width, but soon widens again to three hundred yards, which width it maintains for three and a half miles, to its termination. Between the last-named ridge and the end of the lake three other granite ridges were seen, all having the same northeasterly bearing. These lakes are bordered by extensive tamerack swamps, which also extend between the granite ridges as far as the eye can reach.

At this point is a portage, seventeen hundred yards long, over three ridges of granitic rocks. The portage is a very rough one, the narrow path at many places running along the verge of a deep, rocky precipice on one hand, with steeply-inclined rocks rising to a great height on the other. The rapid, which begins at the foot of the lake, is a very bad one, and falls at one point twelve feet in as many yards. It is about a mile and a quarter long; and the total fall in that distance is, according to the measurement of Col. Whittlesey, seventy-eight feet.

At the point opposite the foot of the rapids, the range is two hundred and forty-four feet high; and at a point on the southern side of the range, measured by Colonel Whittlesey, he found it to rise one hundred and seventy-four feet above the level of the lake. At the "fall" spoken of, the rock (No. 522) is bedded, the beds inclining 46° west-southwest, while the bearing of the range is northeast and southwest. The beds are from ten inches to three feet thick, and are traversed by joints having all the regularity and appearance of cleavage planes. Between some of the beds are thin seams of mica slate, and a few thin seams of quartz were noticed, but no veins of any description were seen. Some of the beds are very decomposable, being made up principally of felspar, which is in large crystals, which cohere but slightly. No. 523 occurs about two hundred and fifty yards below the "fall;" No. 524 is from the middle ridge, and shows the general character of the rock; No. 525 is from the top of the high ridge at the foot of the rapids.

Soon after leaving the rapids the shores of the river were found lined with the rice plant; and the clay-beds, which made their appearance on the northwest side of the last granite range, were occasionally exposed above the water. Between the range, and the mouth of Crane River, there are frequent hills and low ridges, in all of which granitic and metamorphic rocks were seen. About a mile and a half above Crane River, is a ridge of gneiss and mica slate (Nos. 526 and 527), traversed by veins of granite; and a short distance below that stream is a ridge of mica slate (No. 528), which rock is seen occasionally for the next two miles, when we came to rapids, about three hundred yards long, between perpendicular walls of rock of considerable height. On the north side of this ridge is a heavy deposit of dark, yellow, tenacious clay.

As far down as the "Falls of Vermilion," the rocky exposures are frequent, and consist of schistose and granitic rocks, like those already described. The tops of some of the higher ridges are bare, and display most beautifully the ramifications of the granitic veins through the mica slate. The veins are from half an inch to twenty feet in width, and composed sometimes of quartz alone, or of felspar alone, or of a mixture of quartz and felspar, very few being true granite. In some places the mica slate and granitic rocks are so intermingled, that it would be difficult to determine which predominates. No. 529 shows the general character of the mica slate, and No. 530 of the veins which traverse it. At several points there are dome-like intrusions, of a granitic character.

The river bottoms bear soft maple, elms, and oaks, the hills and ridges being covered with yellow pine, cypress, spruce, and poplar. In the expansions of the river wild rice grows.

September 5. The fall which we reached last night, is said to be the highest on this river. It was measured by Colonel Whittlesey, and found to be thirty-one and a half feet, including the rapids above and below. The principal fall is between vertical walls of mica slate, about six feet apart. At the upper chute, the highest perpendicular cascade is eleven feet. After leaving the falls, the rocks, which are rather more thinly laminated than usual, dip south-southeast, at an angle of 35°. Half a mile below, the river is contracted to twenty-five feet in width, and runs between vertical walls of mica slate for the distance of one hundred and twenty yards.

On the south side, the wall is about fifty feet in height, and thirty feet on the north side. The current is very swift, and falls about twelve feet in the distance named. The bearing of the rocks is east-northeast and west-southwest, and the dip 36° south-southeast. There are fewer granitic intrusions here than at most of the other points examined. The few veins are principally felspathic, the felspar being in large lumps and crystals, and decomposing easily. The ridges are covered with a thin bed of clay. Between this place and "Crane Lake Portage," one other ridge was seen, with same bearing and dip. It is about thirty feet high, and has numerous granite veins cutting across the line of strike. Where the granite intrudes, the stratification of the schistose rocks is nearly or wholly obliterated.

At Crane Lake Portage we found a high ridge of rocks, almost bare, in which the relations of the granite and mica slate were very satisfactorily shown. The ridge is about three hundred feet in height, and bears east-northeast and west-southwest. It is traversed by granite veins, which, at some points, are from twenty to thirty feet wide. These veins do not, however, maintain their width for the whole distance they are traceable, but divide into several separate veins, which penetrate between the beds of slate laterally, which gives to the granite, in many places, the appearance of being bedded, and of alternating with the beds of mica slate. These veins also appear always to be wider near to and at the summits of the hills. The mica slate is fine-grained, and very compact and tough between the granite intrusions, while the granite becomes very micaceous. Most of the veins contain but little mica, until they become subdivided and more intimately associated with the mica slate, their constituents being principally quartz and felspar, the felspar predominating.

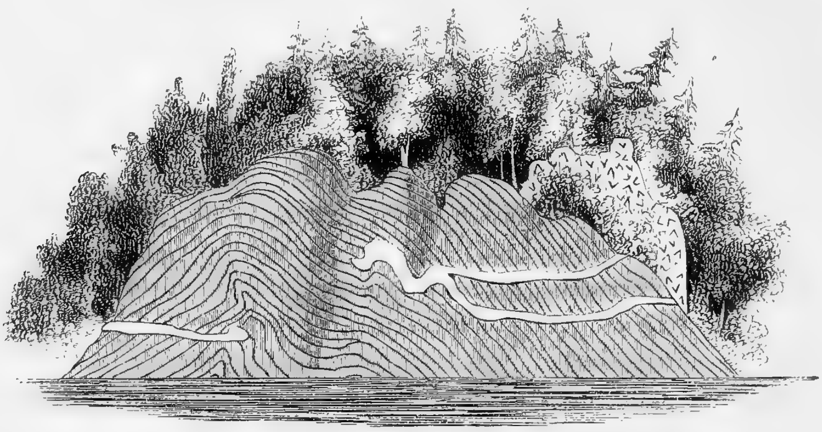
The rapids here are very difficult, and a portage has to be made of everything. Where the river turns around, or, rather, cuts through the ridge just described, it is contracted to twenty feet in width, and runs through a gorge, with mural walls over forty feet in height, for the distance of nearly three hundred yards. From the point where the portage leaves the river above the ridge, to where it strikes it again, on the north side, is about a mile and a half by the course of the stream—the length of the portage being estimated by the voyageurs at two "pauses." The fall at these rapids, as measured by Colonel Whittlesey, is thirty-five feet.

A little over two miles below the portage we entered a narrow *detroit*, which leads to Crane Lake. The shores of the lake are bound with rocks, which become more granitic in character, and just at the termination of the lake, low ridges of granite show themselves. The dip of the schistose rocks, from the lower end of Crane Lake Portage, is north, north-northwest, and north-northeast. The bending and foldings of the slates by the granitic intrusions, are beautifully exhibited at many points on the lake shore, and particularly at the narrow strait which connects Crane Lake with Sand Points Lake, and called by the Indians Wa-bá-bi-kon. At the entrance of this last lake the rocks are all granite (No. 531).

At the north side of Sand Points Lake mica slate again appears, dipping north-northeast, at an angle of 15°. (No. 532.) It is traversed by granitic and felspathic veins (Nos. 533 and 534). A short distance further on, the dip varies from 16° to 44° north, and a little east and west of north. This slate is very finely laminated,

and seems to resist the action of disintegrating forces better than most of the slates hitherto seen. These lakes are filled with small rock-islands.

At a point, called by the Indians Wa-bi-se-gon, near the entrance to Nemakan or Sturgeon Lake, is an exposure of mica slate, with felspar veins, as shown by the subjoined cut, which, from the resemblance of one of the veins to a serpent, is



regarded by the Indians as a *manitou* or god, and must be highly esteemed by them, from the quantity of vermilion bestowed on it, and the number of animals depicted on the face of the rock. The mica slate (No. 535), is much folded and doubled, the veins (No. 537), cutting across the laminæ. This section serves, also, to illustrate the bendings and foldings of the schistose rocks throughout all this region of country.

Nemakan Lake is perfectly studded with small islands of mica slate, dipping to the north at an angle of 14° and 16°. On the north shore, where a portage begins across the ridge between this lake and a small stream which empties into a bay of Rainy Lake, granite was observed protruding through the slate, and bearing east-northeast and west-southwest. During seasons of high water, Nemakan Lake communicates with the stream above mentioned, which is about thirty yards wide, and nine feet below the present level of the lake, where the portage trail strikes it. On this river graphic granite (No. 538) was observed, containing garnets, much actinolite, and some tourmaline.

The rock at the mouth of the river is mica slate (No. 539), with some exposures of No. 538. The bay upon which we entered is called by the Indians Wa-bush-kon-de-ga. The channel leading from this bay is narrow, and shows mica slate on both sides, dipping at a high angle.

I neglected to say, in the proper place, that from representations made regarding the difficulty of finding our way on Rainy Lake, in consequence of the multitude of islands and channels in it, we procured a guide at Crane Portage, from a company of men in the service of the Hudson's Bay Company, who were encamped there for the purpose of trading with the Indians. He was a mere boy, however, and not at all acquainted with the intricacies of the lake, although his father, Menville (who is mentioned in Colonel Long's Narrative of explorations in this region, in connexion with the murder of young Kevenay), represented him as being fully compe-

tent to guide us to Fort Francis. Soon after leaving Wa-bush-kon-de-ga, he became bewildered, and acknowledged his inability to direct our course; and we were therefore left to our own resources, as on Vermilion Lake. We were detained two days on Rainy Lake; one, in consequence of being unable to find the outlet, and the other on account of high winds.

The rocks, which are well displayed on the numerous islands, consist of mica and talcose slates (Nos. 541 and 542), and occasional exposures of granite and gneissoid granite (No. 543). The talcose rocks were met with on the north shore, and the gneissoid granite near the west end of the lake. On an island where we encamped, the mica slate contains innumerable small garnets, and is traversed by granite veins (No. 540), a few inches wide. The tilted edges of the slate are also covered with a *crust* of coarse granite, of a character similar to that displayed in the numerous intrusions seen on the lower part of Vermilion River. It has every appearance of having been spread over the edges of the mica slate from the veins which traverse it. The slate is very hard and compact, and does not seem to weather with as much facility as the granite.

From marks observed on Crane, Sand Points, Nemakan, and Rainy Lakes, their waters appear to rise at some seasons to about five feet above their present level.

We reached Fort Francis on the 9th of September, and were received by Mr. Isbister, the Factor at this post. We remained at this place only long enough to make the portage around the falls, and then started for the mouth of Big Fork River. We were gratified while here by receiving a letter from Dr. Owen, and learning that all his party were well.

While descending Rainy Lake River, a bed of blue clay was observed, similar to that seen and described on St. Louis and Embarras Rivers. It is full of gravel, and overlaid by a bed of yellow sand.

7. *Big Fork River.*—We began to ascend this stream on our way south on the 10th of September. It is about sixty yards wide at its junction with Rainy Lake River, but soon grows narrower, and for several miles is not over thirty yards wide; after which it is increased to forty and fifty yards, which width it maintains up to the mouth of Opimabonowin River. It is very crooked, and winds between banks of clay and sand, from six to twenty feet high for the first twenty-eight miles. The clay-beds are filled with small calcareous gravel and pebbles, as is also the bed of sand. The higher grounds are wooded with small aspen, poplar, birch, bass-wood, ash, spruce, fir, and occasionally a few small pines; and the river-bottoms with elm and soft maple. Where the woods are open, oak is common, and at one or two places hard maple was seen.

The clay-beds resemble those already described on St. Louis River, the bluish-coloured bed being also associated here with a dark yellowish one. On the higher grounds the boulder-drift is seen, and associated with the crystalline boulders are a great many large water-worn fragments of drab-coloured limestone, some of them as much as two feet in diameter. Among these fragments Col. Whittlesey found a piece containing several small bivalve shells and remains of Crinoidea.

About twenty-eight miles above the mouth, the first rock was seen *in situ* (No.

544), exposed just above the water-level; and about two miles further up stream is an exposure of mica slate (No. 545), bearing east by north and west by south. This last rock, like the granite, is exposed just above the water, and at neither place are rapids formed. Above this, the drift-hills increase in height to forty or fifty feet, and clay slides begin to appear in the river-banks. Just beyond the last exposure of rock is a rapid, and three hundred yards further up is an exposure of mica slate (No. 546), on the west side of the river, five feet high, and ten feet high on the east side. This rock is traversed by a dike of greenstone (No. 547), the bearing of which I did not ascertain.

A short distance below the mouth of Opimabonowin River, the river-bed is composed of rock *in situ;* but its character could not be ascertained. Opimabonowin River is about twenty yards wide at its mouth. It heads in the neighbourhood of Red Lake, and is sometimes called the West Branch of Big Fork River. About a mile above the mouth it is crossed by beds of gneiss, bearing northwest and southeast (Nos. 548, 549, 550). This, I was informed by persons in the service of the Fur Company, is the only exposure of rock on that stream. Above this point, rapids become more frequent on Big Fork River. The drift-hills also increase in height, some of them rising fifty and sixty feet above the river-level.

About four miles above the mouth of Opimabonowin is an exposure of mica slate; and three hundred yards before reaching the Falls of Big Fork, greenstone was noticed in the river-bank. The mica slate referred to is traversed by granite veins, and forms a high ridge on the west bank of the river, trending in the direction of the mouth of Opimabonowin.

The falls are about four and a half miles above the mouth of Opimabonowin River. Below them is a long rapid, and the river is wide and shallow. The first rock exposed at the falls, in ascending, is mica slate (No. 551), with large veins of coarse granite (No. 552) ramifying through it. Where it comes in contact with the veins, the mica slate is very hard and compact, and becomes gneissoid in character. Next to the mica slate are beds of gneiss (No. 553), which, in a short distance, graduates into mica slate again (No. 554). Then comes an exposure of slaty greenstone (No. 556), which soon becomes compact. This last rock is traversed by a greenstone dike (Nos. 557 and 558), bearing east by north and west by south, which is also the bearing of the bedded rocks. Near the upper part of the falls, about sixty feet of slaty greenstone is exposed, which, as it recedes from the dike, graduates into mica slate.

The fall at this place is twenty-nine feet in four hundred and ninety yards. In this distance there are five cascades. The channel is slightly winding, and narrow, not being over fifteen feet wide in most places. This is the highest point on the river to which sturgeon can ascend; and I was informed that great numbers are taken every season by the Indians, who encamp here for the purpose.

Three-fourths of a mile above the falls is an exposure of mica slate (No. 560), rather more schistose in character than usual, and bearing, apparently, nearly north and south.

For the next twenty-eight miles, according to my estimate, no rock was seen in place, the river-banks showing clay and sand beds, overlaid by a good soil, with

occasional drift-hills. The bottom-lands are generally from six to ten feet above the usual level of the river, but are subject to overflows in times of high water. Judging from marks left on the trees, the bottoms are then flooded to the depth of three or four feet. The timber is oak, ash, aspen-poplar, bass-wood, soft maple, elm, and some black haw, with a profuse growth of grape and hop-vines. A few large white and yellow pines were seen on some of the hills, and occasionally some cedar.

The first rock met with after leaving the vicinity of the falls was greenstone (No. 561), bearing east by north and west by south. In some places, where it inclined to a slaty structure, the dip was west by south, nearly vertical. About five miles beyond this, we came to an exposure of mica slate (No. 562); and two miles further brought us to the "Little Falls." The fall at this place is six feet. The rock is greenstone (Nos. 563 and 564), with thin seams of quartz traversing it. There is about twelve feet of rock exposed, bearing east-northeast and west-southwest. Near the upper part of the fall are some thin seams of a talcose rock.

About two miles above "Little Falls," a ridge of gneiss (No. 565), crosses the river, bearing east and west. It is the highest ridge of rocks seen on this route, and was estimated to be sixty feet high. A short distance above this is another ridge, about thirty feet in height, but the character of the rock was not ascertained. Eight miles above this, is a rock-island in the river (No. 566), about twenty-five feet in diameter, and rising two feet above the water, which was unusually deep at this place, the men being unable to touch bottom with their setting-poles.

Three miles above the island, hornblende slate (No. 567), again makes its appearance in the river, in a small island, twenty by thirty feet in diameter. Two miles beyond this is an exposure of porphyritic greenstone (No. 568).

The clay-beds still show themselves in the river banks; and the bottom lands begin to bear rich meadows. The rice plant is also frequently seen in the margins of the stream. Back of the meadows are low, rounded hills, some of them covered with grass, and others with cypress and small poplar. Since leaving "Big Fork Falls," the principal timber has been oak, birch, aspen, poplar, fir, cypress, and a few large white and yellow pines. Among the drift deposits large fragments of drab-coloured limestone were frequently met with.

Three miles beyond the last exposure of rock noted, greenstone (No. 569) makes its appearance, and is seen in the river-bed for the distance of three hundred yards; and about five miles further, greenstone (No. 570) again emerges from under the drift, bearing north of east and south of west. From the bearing of these last two exposures, and the course of the river, which runs in the line of strike, I consider them to belong to the same ridge. Six miles higher up the river is a large exposure of syenite (Nos. 571 and 572), bearing north of east and south of west. This was the last rock seen on this river, and is the one on which the drift-hills of the dividing ridge are based.

The river, which, up to this point has been growing narrower for a long distance, is not over ten or fifteen yards in width, at the last granitic exposure. It now becomes wide, and is filled with the rice plant. Five miles above this rapid, we came to another, made by boulders. It is the last one met with in ascending Big Fork River, and we may now be said to have attained the summit-level between

the waters of Big Fork and Lake Winibigoshish. The river, which is exceedingly crooked, continues to become wider, until, eleven miles further up, it expands into a lake, called by the Indians Cut Tooth Lake, which is about three quarters of a mile long, and a quarter of a mile wide. This lake connects with Kashebushkag Lake by a narrow stream a little over two miles long. These lakes, together with the expansions of the river below, have large fields of rice in them. They are bordered in every direction by tamerack swamps, extending as far as vision can reach, with occasional knolls, a few acres in area, rising out of them, and covered with small pine, spruce, aspen, poplar, and birch. In general appearance the country resembles that described as constituting the highlands between Fond du Lac and Lake Pokegoma, and along the upper part of East Savannah River. There are no high hills, nor are there any exposures of rock south of the one last named, in this section of country, the whole region being covered with drift deposits.

A small stream connects Kashebushkag with Round Lake, which is the last of the lakes on this route, north of the water-shed, connecting with Big Fork River. From this lake a portage, one thousand four hundred paces in length, leads to a tributary of Lake Winibigoshish. The gentle swell of land which divides these waters, rises, at the highest point seen, only twenty-five feet above the level of Round Lake. It is the lowest "dividing ridge" we met with in the territory, and there is every probability that the information alluded to in a previous chapter, of the interlockage of the northern and southern streams in this vicinity, is correct.

The small stream down which we descended to Lake Winibigoshish is called by the Indians Ondodawanonan River. It is very narrow and exceedingly crooked, and in these respects resembles very much the upper part of Bois Brulé River, and also West Savannah River. Like this last stream, it winds through wet meadows. It was with great difficulty we got our long canoes around the bends. We found in the bed of this stream numerous fragments of limestone, some of them quite large and thin, and of the same character as the limestone fragments met with on St. Louis and Embarras Rivers, and all along our route from Rainy Lake River to this place. The organic remains contained in them, show them to belong to the Silurian period.

We reached the trading-post on Lake Winibigoshish on the evening of the 19th of September.

8. *The Northern Mississippi, including a Reconnoissance between Red Lake and Cass Lake.*—As the country lying between Lake Winibigoshish and the sources of the Mississippi, has been well and accurately described by Mr. Schoolcraft and Mr. Nicollet, and the country north of their explorations, as far as Red Lake, does not differ materially from that described by them, I shall confine my remarks to a few points deemed of geological and economical importance.

We left the house of the Fur Company, at Lake Winibigoshish, on the 21st of September, and crossing the lake, proceeded up the Mississippi to Cass Lake. Our route from this place led through Turtle River, and the chain of lakes described by Mr. J. C. Beltrami, in 1823, as the "*Julian Sources of the Mississippi.*" I may remark here, that notwithstanding the almost numberless errors and absurdities con-

tained in Mr. Beltrami's "*Pilgrimage*" through this region, relating principally to the manners and customs of the Indians, the map sketched by him of his route is a tolerably correct one, and appears to have been the source from which Mr. Nicollet derived his information with regard to the route between Cass and Red Lakes.

The waters of Lake Winibigoshish differ from those of most of the lakes in this region in not being clear and pure. The Indian name for it signifies "dirty water," and it merits the appellation. This unusual quality of the water is probably owing to some peculiarity of its bed, which, however, was not ascertained. It is about twelve miles in diameter, and destitute of islands, and is shallow for a long distance out from its shores. On the southwest, the shores are lined with tamerack swamps, and on the northeast by gentle elevations, bearing oak, maple, and other hard woods. On the western shore, two long points, made of boulders derived from granitic and metamorphic rocks, extend into the lake. I saw no trap boulders among them, but a number of large limestone fragments. The soil of the higher lands is good, and corn and potatoes can be cultivated to advantage.

Where the Mississippi enters this lake, it is obstructed by sandbars, overgrown with rushes. Within the mouth, the stream is about forty yards wide, and from two to six feet deep, with a sandy bottom, and bordered by low meadows. The bed of the river, after ascending a short distance, is covered with the shells of various species of Unio, and fragments of limestone, which are met with all the way to Cass Lake. At one locality, on the shore, we observed fragments containing several Silurian fossils belonging to the genera *Orthis*, a *Terebratula*, a *Cyathophyllum*, and a *Euomphalus*.

After leaving the lake, the river is skirted by low meadows, which extend to the foot of slopes which rise to the height of from twenty to twenty-five feet, which latter consist of clay-beds overlaid by a stratum of sand and soil, bearing oak and pine, and occasionally ash and cypress. Where the river washes the high banks, frequent slides occur.

Cass Lake has been well and minutely described by Mr. Schoolcraft. The only portion of it we saw, however, was between its outlet and Turtle River. Its waters are clear, and it contains several islands, bearing red cedar, a tree seldom met with in this section of country. Along the shore which fell under our observation, the hills rise to the height of twenty and thirty feet above the lake, and are covered with oak, ash, aspen, pine, and some small birch, while the lower grounds bear a good growth of elm.

A Mission was established at this place in 1844, and has done much towards improving the condition of the Indians. The Fur Company also has a trading-house. The Mission House is beautifully situated, on a hill, forty-five or fifty feet above the lake level, and overlooks the site of the Indian village, which lies between it and the lake, on both sides of the mouth of Turtle River. In addition to the usual bark lodges which compose the Chippewa villages, the Indians here have some good log cabins, which they have erected under the advice and superintendence of the missionaries. Their gardens of corn and potatoes are also more extensive than at most other places visited by us.

The soil at this place is derived principally from the clay-beds, which are found

to extend over this whole district of country. These clay-beds, as has been before remarked, are overlaid by a bed of sand. Where the deposit of sand is thick, the soil is barren, the principal growth being pine and other Coniferæ. It is only where the stratum of sand is thin, and the plough can turn up the clay, that the soil is highly productive. As before stated, in describing other sections of this northern country, these clays contain a great deal of calcareous matter, and, when mingled with the sand, which also contains limestone gravel, form a strong, rich soil. On our return from Red Lake, we were received in the most hospitable manner by Mr. and Mrs. Adams, and Mr. Wright, who are attached to the Mission here.

About a hundred and fifty yards above the mouth of Turtle River, which is twenty-five yards wide, it expands into a small lake, on the slopes around which we noticed gardens of corn and potatoes, cultivated by the Indians. Rather less than half a mile beyond this, we entered another lake, three-fourths of a mile long, and four hundred yards wide. Above this, the channel of the river winds through rice-fields, amounting in all to several hundred acres. Of all this, the produce of scarcely an acre is gathered by the Indians. When it is considered that an acre of this rice is nearly or quite equal to an acre of wheat for sustaining life, the waste of breadstuff in this region, from the indolence and improvidence of the Indians, can be understood.

In this connexion, it may not be out of place to remark that, so far as the mere support of life is concerned, taking into account the amount of labour required to do it, this region is equal, if not superior, to many portions of the settled States. The rice-fields, which require neither sowing nor cultivation, only harvesting, cover many thousands of acres, and yield all that is essential for breadstuff; but, in addition to this, corn can be cultivated with as little or less labour than in the Middle States. Potatoes, far superior in size and flavour to any I have ever seen in the Ohio Valley, are grown with little attention; and turnips and beets produce abundantly. Extensive natural meadows border the lakes and streams, the luxuriant grasses of which are sweet and nutritious, and eagerly eaten by cattle; while the streams and almost innumerable lakes abound with a great variety of fish of the finest quality, and which may be taken at all seasons with little trouble. The uplands are generally covered with a good growth of both hard and soft woods, sufficient for all the wants of man. The sugar-maple is abundant; sufficiently so to yield a supply of sugar for a large population. In addition to all this, the forests are stocked with game, and the lakes and rice-fields must always, as they do now, attract innumerable flocks of water-fowl.

Above the last rice lake mentioned, the river is bordered by meadows, with a skirting of rice along the margins; and beyond the meadows are low ridges, like those on the Mississippi between Winibigoshish and Cass Lakes, bearing the same kinds of timber. The only objects worth noting up to Gnat Lake Portage, were the occurrence of clay-beds, and the entrance of Cormorant River, which is the outlet of Sturgeon Lake. This lake is about fifteen miles north of Cass Lake, and, according to information derived from Mr. Beaulieu, it connects, in a large swamp, with both Lake Winibigoshish and Red Lake. The clays found in this portion of Turtle River are used by the Indians for paint, and also for ornamenting their

canoes. For some distance below Gnat Lake, the channel of the river winds through rice-fields.

Gnat Lake Portage is three thousand six hundred paces long, and leads through a cedar swamp for the first four hundred yards, after which the ground is high, and timbered with pine, cypress, oak, and birch. The soil is sandy, and there is little undergrowth.

Between Gnat Lake and the dividing ridge, the river passes through four other lakes, the last two of which, Turtle Lake and Lac des Morts, are of considerable size. The portage from Lac des Morts is eleven hundred and forty paces long, and leads to Hill Lake, the waters of which flow into Red Lake. The highest point of the portage-path was estimated to be fifty-two feet above the level of Lac des Morts, and the highest ground seen on the east of the portage, was not over twenty feet higher. To the left of the portage is a small pond, connecting with Lac des Morts, and between this and Hill Lake is a low swamp, through which the waters flowing north and south of the dividing ridge must connect in times of high water. The dividing ridge is timbered with oak, ash, aspen, birch, soft maple, bass-wood, and elm.

Hill Lake is about three quarters of a mile long, and half a mile wide, and is the source of Red Lake River. It is not, however, navigable for canoes at its exit from Hill Lake, and a portage is made to Papushkwa Lake. This portage passes over a ridge in all respects like the dividing ridge, except that it is wooded principally with aspen, and has more maple and less oak on it.

On the borders of the lakes south of the dividing ridge, and also in the beds of the streams connecting them, a great many boulders occur, and among them are many fragments of limestone, in one of which (No. 587), I found a *Murchisonia*. On the dividing ridge, and beyond, as far as Red Lake, but comparatively few boulders are met with. Those seen were of granitic and metamorphic rocks. The ridges, as well as the beds of the streams, are made up of fine and coarse gravel. Papushkwa Lake is the largest body of water on the route, and next to that Turtle Lake. They both contain islands, and deep bays divided by long narrow points of land.

Where Red Lake River emerges from Papushkwa Lake, it is about fifteen feet wide, and obstructed by rushes and reed grass, but after some distance, it expands into small lakes, filled with the rice plant. About seven miles below the lake, the stream ceases to be navigable for canoes, and "Red Lake Portage" begins. So far as depth of water is concerned, the stream is navigable to Red Lake, and it was the route formerly pursued by the traders in the transportation of their goods. But in consequence of numerous obstructions from fallen timber, it has been disused for a long time, and is now so overgrown with alder bushes that a canoe cannot pass. It is also very crooked, and would require more time for its passage than it takes to make the portage, which is about fifteen miles long.

Several small lakes were seen in the first four miles of the portage, the shores of which were timbered with oak, maple, ash, birch, aspen, and elm; and one mile further, low sandy ridges begin, covered with a growth of small aspen, with an undergrowth of bass-wood. For the next five miles the country is gently undu-

lating, with meadows in the valleys, and aspen, pine, birch, and cypress on the higher grounds, with an undergrowth of maple and bass-wood.

Between three and five miles south of Red Lake, we passed three high barren ridges, and one low one, with very steep sides, and separated by narrow valleys. These ridges bear nearly northeast and southwest, and are composed of sand, intermingled with gravel and pebbles, derived from both crystalline and sedimentary rocks. The bases of these ridges are, probably, the extreme southwestern prolongations of the low granite ridges seen on Big Fork River, below the mouth of Opimabonowin River. North of the ridges is a valley about three-fourths of a mile wide, thickly covered with small cypress. The most northerly ridge (the one next to Red Lake) rises only eleven feet above the valley, and is very little higher than the land near the Lake shores. The next one south of it is fifty-three feet above the intervening valley; and the third one is sixty-six feet above a small stream which flows in the valley between it and the second one; while the summit of the fourth, or most southerly one, is eighty-two feet above the bottom of the valley between it and the third. These ridges are not timbered; only a little coarse grass and a few scattering bushes grow on them. The valleys support a small growth of such timber as was seen on the rolling lands immediately south of them.

Very few boulders were seen in this section, and most of those noticed were derived from the metamorphic schistose rocks, such as were met with on Big Fork River, and along the northern line of exploration. Some few granite blocks were seen, with angular outlines.

Beyond the cypress valley mentioned above, the ground rises gradually, until the general level of the belt of land immediately bounding the south shore of the lake is attained. We reached Red Lake on the 24th of September, and were most kindly received by Mr. and Mrs. Ayer, Mr. and Mrs. Wright, and Dr. and Mrs. Lewis, of the Mission here.

The lake—which is the largest of all the small lakes in the Territory, being about thirty miles in diameter—is a double one. It is divided by two long peninsulas, which project into it from its eastern and western sides, into nearly equal portions, the strait connecting them being about two and a half miles in width. It contains no islands, and is represented as being very shallow in proportion to its size. Its general shape, and the relative position of the two divisions, can be better understood by consulting the map than from any description I could give, especially as no survey was made of it. The position assigned it on the map is in accordance with the observations of Col. Whittlesey, which were made on the south shore, partly at the house of the Fur Company, and partly two miles west of it, at the Mission. The outlet of the lake, which is a tributary of Red River of the North, is in the southern division, near the base of the western peninsula. The eastern peninsula is represented as being the site of Indian gardens, and bears northeast and southwest, and is, therefore, parallel with the high ridges south of the lake.

The Mission, which was established at this place in 1843, has been of great service to the Indians. Under the instruction and example of the missionaries, and by their assistance, a large tract of land has been cleared by the Indians, in which they cultivate fields of corn and potatoes. In 1848, three thousand bushels

of corn, and two thousand bushels of potatoes, were raised by them, besides squashes and other vegetables in abundance. A number of the Indians have good log houses; and their bark lodges are larger and better appointed than in the generality of Indian villages.

The strip of fine land on which the farms are situated is about eight miles long, and from a quarter to three quarters of a mile wide, and is situated along the south shore of the lake. South of this belt, the soil is sandy and covered with pine and cypress, but is said to grow excellent oats.

The houses of the missionaries are good and comfortable; and their farm is kept in as good order and is as well cultivated as any farm in the States. It is really what it is intended to be, a "model farm," and the happy results of their example are seen all around them, in the well-cultivated fields of the Indians, and the excellent cabins of many of them.

We left Red Lake on the morning of the 26th, and returned to Lake Winibigoshish over the route already described.

On the 30th of September, we left Lake Winibigoshish, and began to descend the Mississippi. At the outlet of the lake, the river is about sixty yards wide, and maintains this width for nearly two miles, when it expands into a small lake, a mile and a quarter in length and about half a mile wide. This lake is worthy of notice as being the last one, except Lake Pepin, through which the Mississippi passes in its journey to the sea. After leaving this lake, which is called Little Winibigoshish, the river runs through reed-grass swamps, and is frequently divided into a number of narrow channels. At some points it contains a narrow border of rice.

The land at the outlet of Lake Winibigoshish is sandy, with a tolerably good soil. There is a large proportion of hard woods in all this section, and it is generally the case, that when the Coniferæ are burnt off, a growth of oak, maple, ash, aspen, and birch, springs up.

The river-bed contains a great many small and some large boulders. They are principally granitic; and in some places exist in such quantities as to give rise to slight rapids, like those described in a previous section as occurring between the mouths of Crow Wing and Sandy Lake Rivers. I did not, however, at any point along this portion of the Mississippi, see boulder-beds underlying the clays, though I think it highly probable that they do. The river is from two to six feet deep, and where it washes the base of the ridges, good sections of the sands and clays of which they are composed are often exhibited. The top stratum is a coarse yellow sand, resembling fine-grained brown sugar, and is from three to four feet thick. It rests upon a bed of fine white sand, with small gravel in it, very much like that seen in the sand ridges south of Red Lake. Beneath this are the clay-beds. Below the mouth of Leech Lake River, many springs issue from above the clay-beds, strongly impregnated with iron. Colonel Whittlesey met with one containing sulphuretted hydrogen.

The river is exceedingly crooked, and winds through broad savannas overgrown with meadow and reed grasses, and intersected by sloughs in every direction. Oak Point is the only place where canoes can land for the distance of many miles, and

is distinguished in Indian tradition as having marked, for a long time, the northwestern limit of the Chippewa possessions. We learned from one of our voyageurs, that when the grass is burnt off the Point, the forms of a great number of ancient lodges can be seen, which were so constructed that the floors are sunk below the surface of the ground. We saw two circles, each about thirty feet in diameter, raised a few inches above the general level, and the area inside was apparently excavated to a slight depth. Near them, and at the most projecting point of land, is a mound, about forty feet in diameter at the base, and five feet high. It is a circle, and on the side next the land is a narrow raised pathway, leading to the top. Just where the pathway terminates are the remains of the stump of a large oak. The top of the mound commands a view of several miles across the savannas, up and down the river. The voyageur alluded to says that the smaller circles are arranged in one great circle, the mound forming the centre of the ring next the river; and that the remains of earthen pots have been frequently found here.

The river continues to flow through wide savannas for a long distance below Oak Point, when the ridges begin to approach nearer and nearer, and occasionally come up to the margin of the water, exhibiting sections of the sands and clays described above. After passing the mouth of Pokegoma River, the high banks on both sides continue to approximate until the Falls are reached. The higher grounds are wooded with pine, and the lower ones with oak, birch, and aspen.

The summit of the ridge of rock at the "Falls of Pokegoma," is forty-one feet above the water-level below the fall, and bears east by north and west by south. This is the only exposure of rock, in place, on the Mississippi, from its sources to the mouth of Omoshkos or Elk River. The river has cut a deep channel through the rocks, and falls twelve and a half feet in two hundred and fifty yards. The rock is well exposed in the walls of the channel, and on the west side of the river, for the distance of several hundred yards. It consists principally of quartzite (No. 586) on the sides of the ridge, and of granite (No. 584) in the centre. The great body of rock exposed is altered or metamorphosed sandstone; and in the midst of the fall, where it is subjected to the constant action of water, it becomes soft, and differs very little in general appearance from the sandstones of the Chippewa and Lower St. Croix Rivers (No. 585). Where the quartzite is in near contact with the granite, it is sub-porphyritic.

This ridge is called by the Indians *Ish-ko-na-bi Wachu*, and in its northeasterly prolongation, forms the dividing ridge between the waters flowing north into Rainy Lake River, and those flowing south into the Mississippi and into Lake Superior; and which takes the name of Missabé Wachu between Upper Embarras and Vermilion Rivers. Continued in a southwesterly direction from the Falls of Pokegoma, this ridge would pass south of Leech Lake, and separate its tributaries from Willow, Pine, Gull, and Crow Wing Rivers, and other tributaries of the Mississippi, and strike Red River of the North near the Great Bend, at which point Dr. Owen found Silurian rocks, in 1848.

These facts, taken in connexion with the general structure of the country, lead me to the conclusion, that the heavy drift deposits lying between the great southwesterly reach of the Mississippi, extending from Sandy Lake to the mouth of

Crow Wing River, and the range of hills just described as stretching away in the direction of the sources of Red River of the North, is underlaid by sedimentary rocks of the same age as those found on St. Peter's River, and also on Wisconsin, Chippewa, St. Croix, Kettle, and Snake Rivers.

Ishkonabi Ridge is covered with a dense growth of good pine, which is said to abound in the country around Lake Pokegoma, and on a number of the small rivers in this section.

Below the mouth of Prairie River, and as far as Blueberry Creek, the country is open, with belts and clumps of small pine on the higher grounds, and elm, maple, and oak, in the bottom lands. Below Blueberry Creek the country is more densely wooded, and resembles, in all respects, the country lying between Rabbit and Sandy Lake Rivers. Between the Falls of Pokegoma and the mouth of Sandy Lake River, the clay and sand-beds are well exposed, at numerous points. The clay-beds vary from two to thirteen feet in thickness, above the water-level; and the overlying sand-beds are from five to eight feet thick. The prevailing colour of the clay is red, and at some places it is highly ferruginous, and filled with gravel.

We got to Sandy Lake on the 3d of October, and were kindly received by Mr. and Mrs. Spates, who have charge of the Mission there. Next morning we left Sandy Lake, on our way to the mouth of Mud River.

SECTION IV.

NARRATIVE OF EXPLORATIONS, MADE IN 1848, ON MUD RIVER, MILLE LACS, AND RUM RIVER.

At the mouth of Mud River, Col. Whittlesey and myself left the Mississippi, with one canoe and two voyageurs, for the purpose of examining the country around Mille Lacs, and along the borders of Rum River; while Mr. Beaulieu, with the other canoe and voyageurs, descended the Mississippi to the St. Peter's, carrying the collections made during our reconnoissance in the North.

We began to ascend Mud River on the 6th of October. It is a small stream, from twenty to twenty-five feet wide, very crooked, and much obstructed by boulders. The general level of the country near its mouth is from ten to fifteen feet above the usual level of the Mississippi, and so continues up to Hanging Kettle Lake. The timber is small and sparse, and consists of aspen, oak, birch, and elm, with a few scattering pines. Around Hanging Kettle and Mud Lakes, through which the river flows, drift-ridges make their appearance, rising to the height of fifty feet above the water, and are covered with small oaks, maple, ash, and pine. Of the three lakes through which the stream flows in this part of its course, Mud Lake is the largest, and is about one mile long and half a mile wide. Boulders are numerous on the ridges and in the valleys, and consist of granite, greenstone, and amygdaloid.

Above Mud Lake the river makes a great bend to the southeast; and, in order to reach Mille Lacs by the shortest route, we made a portage of three-quarters of a mile, and struck the river a long distance above the point where we left it. When

we embarked again, our course was down stream until we reached the point of the great bend nearest Mille Lacs. This part of the river is wide, deep, and filled with wild rice, and is bordered by extensive tamerack swamps, the trees scattered through them being mostly dead, and exhibiting a scene very similar to that described in a previous chapter as occurring on Lac du Flambeau River. The swamps are intersected by occasional narrow ridges, bearing both hard and soft woods.

Mille Lacs Portage is about two miles long. The first quarter of a mile passes over drift-hills. Between these hills and the Lake is a strip of as good land as I have seen in the Territory, timbered with maple, oak, ash, bass-wood, and birch. It is gently undulating, and admirably adapted for agricultural purposes. A few small meadows occur in this body of land, and granitic and other boulders are met with on its surface, but not in sufficient quantity to interfere materially with its cultivation.

Mille Lacs is the largest body of water in the Territory southwest of Lake Superior, being about eighteen miles from north to south, and fifteen miles from east to west. On the east side, about one-third the distance down from the north shore, is a point projecting into the lake, and composed of large boulders. The land along the east shore is well timbered with oak, maple, ash, elm, birch, and aspen. The shore is from four to twelve feet high, and walled with a line of boulders, some of which are remarkably large. The lake is shallow for a long distance from the shores, and the bottom entirely covered with boulders. Southeast of the point named above is a tamerack swamp, the level of which is lower than that of the lake,—the lake being walled in by a bank ten or twelve feet high, composed of boulders and soil. This heaping up of boulders so as to form barriers higher than the surrounding country occurs also at many other points. At one place the boulders present an inclined wall, ten or eleven feet high, for a long distance; while the general level of the country is not over seven or eight feet above the waters of the lake. In the southeasterly portion of the lake are several small islands, composed entirely of boulders, piled up sometimes as high as twenty feet. Around one of these islands is a wall of boulders several feet higher than the centre, the formation of which, as well as of the lake barriers, I attribute to the action of ice. On the west side of the lake, near its outlet, is a projecting point, bearing northeast, and in that direction corresponds with the point mentioned on the east shore, and marks, probably, the course of a granite ridge concealed beneath the drift. The boulder-islands, also, are, in all probability, based upon the granitic rocks, which are known to underlie this section of country. Near the point is the largest island in the lake, and the only one covered with a good soil: on it the Indians have gardens. The ridge forming the point is covered with pine.

Rum River is about twenty-five feet wide at the outlet of Mille Lacs; in less than a mile it expands into a rice lake, about three miles long, and a quarter of a mile wide. The country at the lower end of the lake is from twenty-five to thirty feet above the level of the water, and is well timbered with large maple, oak, elm, and ash. It is comparatively free from large boulders on the surface. Two other lakes occur in the distance of about five miles, both filled with rice. The last one

is about two miles long, and three-quarters of a mile wide. The shores are low, and covered with oak, and some birch and pine. On the east side, some of the pines are first-rate in size and quality.

About ten miles below this lake, following the meanders of the river, and probably five in a direct line, is an exposure of five feet of syenitic granite (No. 573), which soon gives place to hornblende rock (No. 574); and one hundred and fifty yards lower down the river, is a quartzose gneiss (No. 575), associated with granite (No. 576). These last rocks are traversed by granitic veins (No. 577). At this last place is a rapid, which is called by the Indians Ka-ka-bi-kause, or "Little Falls," although the highest ledge of rock crossing the river is only one foot perpendicular. The bearing, as nearly as could be ascertained, is northeast and southwest. The rock is exposed for a hundred and fifty yards in the course of the stream, which is about forty feet wide, and when we descended it, only six or eight inches deep. About five hundred yards below this place is an exposure of greenstone (No. 578). Below this the river makes a considerable bend to the east, and in the next five miles, following its course, which is very crooked, are four other exposures of rock. The first one, a quartzose granite (No. 579), is three miles below the greenstone; the second one, two miles lower down the stream, is syenitic granite (No. 580); the third may be set down as a hornblende rock (No. 581), and occurs one mile below the second, or No. 580; and the fourth and last exposure on Rum River, is syenite (No. 582), associated with a rock composed of quartz and felspar (No. 583) in large veins. These rocks continued southwesterly in the line of bearing, and strike the Mississippi between the mouths of Platte and Sauk Rivers, where their associations and lithological characters are the same as on Rum River.

Below Ka-ka-bi-kause, on both sides of the river, for the distance of ten or twelve miles, the country is timbered with first-rate pine, mingled with large maple, oak, and ash, with a smaller growth of birch, aspen, and spruce. Between the ridges are narrow cranberry swamps and wet meadows. The drift-banks come up to the river, and are from thirty to forty feet high. Lower down, the country becomes more rolling, and the river-banks have a long slope back to the general level, which is from fifty to sixty feet above the water. The higher lands are still timbered with large pines, and the woods named above.

Continuing to descend, the pine begins to fail in quantity and quality, and large tamerack swamps are found between the ridges; while the river-bottoms increase in width, and are covered with oak, soft maple, elm, ash, willow, and alder. The undergrowth is very thick, and consists of hazel, prickly ash, chokeberry, rose-bushes, gooseberry-bushes, and high-bush cranberry. The pines are now thinly scattered along the crests of the ridges, and are small and knotty. Clay-beds are frequently exposed, from five to six feet in thickness, overlaid by ten or twelve feet of sand, with boulders in it. The large boulder-drift is five or six feet below the soil, and underlaid by beds of sand and pebbles. The river is now much obstructed by drift wood, forming rafts, and becomes narrower and deeper. The banks are from six to twenty feet high, the general level being from twenty to

twenty-five feet above the water. The bottom lands all overflow to the depth of several feet during freshets.

Eight or nine miles before reaching Snake River Portage, slight rapids begin to occur, made by lines of boulders and pebbles crossing the river, similar in all respects to the rapids observed on the Mississippi between Crow Wing and Sandy Lake River. The clay-beds are also exposed at these rapids, associated with coarse, ferruginous sands. Four or five miles nearer the portage, there is five feet of clay, overlaid by fifteen feet of sand. In the upper part of the clay-bed, are a great many small boulders of crystalline rocks, and also a large proportion of fragments of ironstone and limestone. The limestone is similar to that found on St. Louis, Embarras, Big Fork, Ondodawanonan, and the Northern Mississippi Rivers. The clay-beds undulate, as they do on the Mississippi. They are stratified, and dip, at many points, at an angle of four or five degrees. The sands which overlie them follow the bendings of the clay-beds, and are almost always best developed where the clays are best displayed. The great boulder deposit is in the upper part of the sands; and below the sand-beds, in the upper part of the clay, is the deposit of small boulders before alluded to. The deposit of fragments of ironstone is in the lower part of the sands. The middle bed of sand is white, while the upper and lower beds are yellow, the lower one being often highly ferruginous, with numerous large thick crusts, cemented by oxide of iron.

The country continues the same, except that the hills and ridges are higher, and have a few second-rate pines scattered over them. The river is very crooked, and in addition to the usual trees in the bottoms, I noticed hackberry, butternut, box-elder, and haw.

Below Snake River Portage, high rolling prairies begin, with clumps of dwarf oak scattered over them. The soil is thin, and rests on sands from thirty to forty feet thick. The river is from twenty to forty yards wide, and the bottoms become narrow, with few or no trees on them. Boulder-rapids now become more numerous, until the mouth of the river is reached. Along the lower part of the stream the country rises in terraces; the lower terrace consisting of the clay-beds, with six or eight feet of bedded sands over them; and the upper terraces of heavy sand deposits, with large boulders in the top part. On the lower terraces red cedar was seen at many points.

We got to the mouth of the river on the 17th of October, and on the 18th reached St. Peter.

CHAPTER IV.

PHYSICAL STRUCTURE AND GEOLOGY OF THE NORTHWESTERN AND WESTERN PORTIONS OF THE VALLEY OF LAKE SUPERIOR.

SECTION I.

PRELIMINARY REMARKS.

In connexion with some notes on the physical structure of the country lying between Pigeon River and the Grand Portage of St. Louis River, on the north, and Bois Brulé River and Fond du Lac Supérieure, on the south, and forming part of the western portion of the Valley of Lake Superior, it is deemed not out of place to call to recollection a few facts with regard to the structure of certain portions of the Western and Northwestern States, which tend to confirm and elucidate, in my opinion, the geological observations made in the region of the great Lake, and to support the conclusions drawn from them; and also to throw some light on several obscure points in the geology of certain other portions of the Chippewa Land District. I shall not, however, enter into minute details, nor attempt to discuss, here, the conclusions which these facts have given rise to; nor will an endeavour be made to fortify them by the adduction of numerous facts of a similar character, which might be brought forward from every portion of the valleys of the great lakes, as well as from the entire Valley of the Mississippi. A simple reference to them will be sufficient to suggest to every one their applicability to the subjects of this chapter.

As what I conceive to have been great valleys in the rocky strata of large portions of Wisconsin and Minnesota, have been filled up, and the country, in a great measure, levelled by the accumulation of immense deposits of drift, it is not possible to determine, with anything like accuracy, the width of the original valleys, nor the exact lines of the anticlinal axis separating them; but the distances from one synclinal line to another may be ascertained, now, with as much precision as the linear surveys of that region, together with the drafts of the principal streams in the unsurveyed portions of territory, by members of the Geological Corps, will

permit. Thus: from the Valley of Chippewa River, at the mouth of the Manidowish, to that of the Upper St. Croix, in a direct line, and at right angles to the course of the valleys, is about sixty miles; and from the Valley of the St. Croix to that in which the Mississippi flows, between the outlet of Sandy Lake and the mouth of Crow Wing River, in the same direction across the strike of the valleys, is about sixty-two miles; and from this portion of the Valley of the Mississippi to the next parallel valley—the one in which Leech Lake is situated—is about fifty miles; and from the Valley of Leech Lake, to the next great parallel valley northwest of it—the one in which Red Lake lies—is about sixty-eight miles; showing a remarkable degree of uniformity in the undulations of the crust of the earth throughout a very extensive region of country. These valleys, together with others to be mentioned, may be traced by the courses of their streams for great distances, and, when taken in connexion with the shores of Lake Superior, for several hundred miles.

There are three great systems of valleys in the Northwest, besides numerous subordinate ones; the valleys of each system preserving a very uniform degree of parallelism with one another, and with the smaller valleys between the anticlinal axes.

The first system includes the Valley of the Chippewa, throughout nearly the whole course of the river; the Valley of St. Croix River, from its source to the mouth of Crow Wing River; the Valley of the Mississippi, from the outlet of Sandy Lake to Crow Wing; the Valley of Minnesota River, from its mouth to the mouth of Lesueur River; the west end of Lake Superior, from Fond du Lac Supérieure to the mouth of Pigeon River, and as far as Thunder Cape; and, northwest of the Lake, the Valleys of Cloquet and Big Whiteface Rivers; that of St. Louis River, from its source to the mouths of the Two Rivers; and of Upper Embarras River, from its source to Ininiwishtigonon Lake. The valleys of all these streams run northeast and southwest.

To these may be added, the Valleys of Illinois River, from near Hennepin to Naples; of Rock River, from its source to Grand Rapids; of Wisconsin River, from Winnebago Portage to its mouth; of Kaskaskia River, from its source to Athens; of the Ohio River, from Beaver to the mouth of Big Sandy River, and from Lawrenceburgh to Cairo; of the Mississippi, from Beaver Island to Muscatine, and from the mouth of the Missouri to Herculaneum; and of the Wabash, from its source to Westport.

The valleys included in the second system are at right angles to the first. Among them may be mentioned those of St. Louis River, from Knife Portage to the mouth of East Savannah River; of the Mississippi, from the mouth of Swan River to Lake Winibigoshish; from the mouth of Clear-Water River to the mouth of Prairie à la Crosse River; and from Hannibal to the mouth of the Missouri; of the Des Moines, throughout nearly its whole course; of Minnesota River, from its source to the mouth of Lesueur River; of Crow Wing River; of large portions of Snake and Kettle Rivers; of large portions of Big Fork and Little Fork Rivers, and nearly the whole of Vermilion River; and of Pigeon River, and the chains of lakes which

mark the boundary line between the United States and the British Provinces from Lake Superior to Rainy Lake. These valleys all have a northeast and southwest bearing, and preserve a uniform parallelism, with a few exceptions, for short distances; and these exceptions will generally be found, on investigation, to maintain a parallelism with one of the two other systems, or to be complicated by the traversal of subordinate axes, to be mentioned hereafter.

The third system of valleys runs north and south, or nearly so, and includes the Valleys of Wisconsin River, from near its source to Winnebago Portage; of Red Cedar River (Menominie of the Chippewas); of St. Croix River, from the Falls to the outlet of Lake St. Croix; of Rum River, from Snake River Portage to its mouth; of the upper two-thirds of Snake River; of St. Louis River, from the Two Rivers to the mouth of East Savannah River; of Bois Brulé River; of Illinois River, from Naples to its mouth; of the Wabash, from Darwin to Vincennes, and from the Grand Chain to its mouth; of the Mississippi, from Crow Wing to the mouth of Clear-Water River, from the mouth of Root River to that of Turkey River, from Savannah to Bear Island, from Keithsburgh to Oquawka, from the mouth of the Des Moines to Hannibal, and from "Grand Tower" to Cape Girardeau; and of Red River of the North, from its Great Bend to its entry into Great Lake Winnipeg. These valleys are parallel to the basin of Lake Michigan.

To this list might be added the Missouri River, which maintains a southeasterly course from the mouth of Chayenne River to the mouth of the Kansas, and is, therefore, parallel to the Mississippi for several hundred miles. The valleys of numerous smaller streams might also be enumerated, all maintaining a parallelism to one or other of the three great systems of valleys named, and all tending to support the opinion that the great structural features of the country are due to subterranean movements, acting at different periods on an immense extent of the crust of the earth, and with great uniformity during each epoch; and not to local disturbances only, or to mere alterations of the surface from glacial or diluvial action, however much these agencies may have altered the face of the country.

As will be seen from the report of details of the geology of the country north of the western portion of Lake Superior, a large district has been subjected to disturbances of a more local character, and at various periods; and that they extended into the great valleys named, and gave rise to numerous local variations in the strike of ridges and the direction of subordinate valleys. Judging, however, from the great degree of uniformity exhibited in the various systems of trap rocks exposed along the Lake coast, and as far north as the water-shed, there can be but little doubt that the same degree of uniformity and parallelism is maintained throughout the whole extent of country southwest of Lake Superior, where trap dikes are found to penetrate the metamorphic and more recent sedimentary strata, at various points, as far as the Mississippi; and that the various directions of subordinate hills and valleys would be found, on examination, to conform to some one or other of these systems.

Relatively, the high ranges and chains of hills, which begin in Canada and cross into Minnesota north of Lake Superior, may be termed mountains, although they

only rise to the height of between twelve and thirteen hundred feet above the Lake, at the highest points in our territory, and less than two thousand feet above tide-water. The valleys between these mountain-ridges are often from five to six hundred feet below the summits, and vary in width from one or two miles to narrow gorges not over two or three hundred yards across.

The scenery of the whole extent of the ranges north of the Lake, is bold and picturesque. The outline of the chains of hills and ridges is very irregular, and characteristic of the rocks which compose them. Some of the hills are round-backed, some of them angular, and others jagged, with an occasional peak here and there, but no spires. In the trap region, rugged mountain scenery prevails; in the schistose and granitic belt, occasional knolls or low ridges, with intervening lakes or swamps, make up the scene; and in the drift region, lines of conical hills, irregular depressions, and low ridges with long slopes, constitute the main features of the country. The rivers have numerous falls and cascades, and, in the small, deep valleys, often expand into beautiful lakes, the clear waters of which appear almost black, under the dark shadows of the high rocky walls which enclose them.

The lines of eruption are various, and the materials thrown out differ greatly; but they agree in the various parallel lines to a very near degree. There are five principal axes of elevation, due to eruptions: east 45° north; north 45° west; north and south; east and west; and north 30° east. The first three of these, as already stated, stamp their impress on the general features of a large district of country. The first of the other two principal axes is best developed between Pigeon Point and the mouth of Kamanosisatikag River, and the second between Fond du Lac Supérieure and Two Island River; but they are discoverable at various other points, as far south as the Falls of the St. Croix, and as far north as the dividing ridge between the waters of the Mississippi and Hudson's Bay. As a rule, almost without exception, the narrow dikes which run parallel with the principal axes are composed of materials similar to those of the heavy ridges and dikes having the same direction.

The direction of the shores of the western portion of Lake Superior, and the width and configuration of all that portion lying between a line drawn north-westerly from the Apostle Islands to the mouth of Two Island River and Fond du Lac Supérieure, shows the correspondence of the basin of that part of the Lake with the valleys of the large streams south and southwest of it.

The range of greenstone ridges which begin at the Great Bend of St. Louis River, and run northeasterly (north 30° east), form a true anticlinal axis,—the line of elevation crossing the boundary line between the sources of Arrow River and Mountain Lake. And, although this range, and the north-45°-east one, which begins near the same point, impress the features of the country northwest of the Lake most prominently (modified in the easterly portion by the heavy east and west dikes), still, the structure of the whole region is greatly complicated by the numerous narrow dikes which traverse it in other directions.

In consequence of the greater facility with which granitic rocks decompose, the hills and ridges along the northern water-shed are lower, in relation to the valleys

between them, than those in the hornblendic and trap region. They are also more rounded; and the scenery is destitute of that bold and picturesque character which the greenstone ridges impart to it.

The elevating forces appear to have acted with equal energy on both sides of Lake Superior: the elevation of the granitic water-shed, which passes into Wisconsin between the sources of Montreal River and Portage Lake, and pursues a southwesterly course, being nearly or quite as high above the sea-level as the highest range of granite hills north of Lake Superior. The highest ridge met with on the "boundary-line," where the waters divide, was only 1260 feet above the lake-level; while the water-shed south of the Lake was found to be 1150 feet above the same level, or nearly one hundred feet higher than Ashawiwisitagon Portage. That the periods of eruption and elevation were as distinct and various as the different systems of dikes, is conclusively shown by the disturbance of the different strata of sandstones, shales, and grits, and the conglomerate beds met with at different localities, and by the variations in the dip of the bedded rocks, in accordance with the direction of the lines of disturbance.

While there is great uniformity in the dip of the rocks over the whole extent of country between Lake Superior and the Mississippi, the greatest confusion prevails on the northwest shore of the Lake, in consequence of a want of parallelism in the ridges and dikes of the various eruptive periods. The volcanic grits, which make up a portion of the series of the Lower Silurian period, do not extend the whole length of the coast, and this, again, is productive of confusion when the whole series comes to be compared at different points. The great amount of denudation or erosion on the north shore, also adds much to the complexity of its geology, especially with respect to the eruptive rocks. The stratified rocks, however, are well defined at some localities, and afford material aid in elucidating the associations of the others.

The northern mountain range dies out in a great measure after crossing St. Louis River in its course southwest, but the granitic, metamorphic, and trap rocks are met with at various points along the line of bearing, in the beds of the streams, and rising in low knolls through the drift, as far as the Mississippi, which they cross, as before stated, between Omoshkos and Clear-Water Rivers, and reappear again, in the line of bearing, on Minnesota River, between the mouths of Red Wood and Little Waraju Rivers.

In their general line of direction, few of the chains of hills north of Lake Superior tower to any great height above the others. On the tops of the high ridges the rocks are sometimes bare, but are generally covered with mosses and lichens, and a stunted growth of evergreens. The naked rock, which is sometimes several acres in extent, is generally smooth, often polished, and almost always exhibits numerous parallel lines of scratches and grooves.

Before proceeding to give the details of the examinations made north of the west end of Lake Superior, it may be well to refer again to the fact, that between Fond du Lac and Pigeon River, the Lake shore conforms in its general direction to the line of bearing of the ranges of trap which begin at the Grand Portage of St. Louis River, and proceed in a northeasterly direction toward the Falls of Kamanitiquoia

River and the head of Thunder Bay. In other words, the Lake shore has the same bearing as the trappous and altered rocks which lie contiguous to it, namely, northeasterly and southwesterly. Along almost the whole of this line the shore is rockbound; the rocks rising from the water in escarpments, many of them mural, from ten to two hundred feet in height, and presenting an almost unequalled section of igneous and altered rocks. At no points are sloping wooded plains to be seen, such as bound the Lake on the south shore at many points in Wisconsin, between Fond du Lac Supérieure and Montreal River.

The shore is indented by numerous small bays and pockets; none of them very deep, however, but sufficiently so to afford many valuable sections, which serve to show the relations between the igneous and sedimentary rocks. Occasionally, the hills rise abruptly from the shore to the height of two or three hundred feet; but, generally, after rising from ten to forty feet above the water, there is a gradual ascent to the summit of the first ridge, the lower part of the slopes often being covered with cedar swamps. The ridges generally increase in height as they recede from the shore. The declivities on the lake side are almost always abrupt near the top, while on the opposite side the descent is rather gradual from the summit to the valley which intervenes between it and the next subordinate ridge. Through these valleys, which are often little more than ravines, the streams which drain the country between the Lake and the summit-level, wind their way; running, sometimes for long distances, in the line of bearing of the rocks, and at others intersecting the ridges in their course. At the same relative distance from the lake-shore, the height of the ridges is about the same; the highest measured by me being a little over nine hundred feet above the lake-level, and between four and five miles in a direct line from the Lake. As a general thing, the subordinate ridges are short, with abrupt terminations, and vary considerably in height. This gives to the ranges a peculiar, broken, craggy outline, which contrasts forcibly with the hills of granitic and schistose rocks met with still further north, and which are more or less regularly rounded.

At the bottom of many of the bays, the beach is low, and covered with boulders, derived not only from the neighbouring rocks, but also, and probably in greatest proportion, from the granitic rocks which lie to the north. The boulders, by the conjoined influence of storms and ice, are frequently heaped up along the beach of the small bays, at the distance of fifty or one hundred yards from the water, to the height of eight or ten feet above the lake-level, like barriers; the intermediate space being occupied by sand and pebbles, among which a great many siliceous minerals are found, as, different varieties of quartz, agate, carnelian, chalcedony, and jasper. The beaches are rarely more than one or two hundred yards in length, and can only be approached by canoes or other very small craft. At several points, however, boats of considerable size could effect a landing, and, in several of the small bays, remain sheltered from storms. Near the shore the water is generally shallow, and deepens as you advance into the lake, in conformity, apparently, with the dip of the rocks which bind the shore at each particular place. As the eastern part of the District is approached, the bays become deeper, and often narrow, and are bounded by high mural walls of rock, which, in one or two instances, rise to the

height of six hundred feet. These bays owe their existence, shape, and extent, to the numerous trap dikes, with various bearings, which traverse all this region.

The streams which empty their waters into the Lake along the northwest shore, are all small, and the valleys through which they flow, narrow. From six to ten miles before they reach the Lake, most of them cut their way through the softer trap and metamorphosed rocks, and often flow through narrow gorges, with mural walls of considerable depth. The wear of the rocks which form the beds and walls of the water-courses, has been great throughout the whole District, but especially so in that part lying south of the Fond du Lac and Mountain Lake Range; where, after following the strike of the valleys for various distances, they cut through the rock ridges, and finally mingle their waters with those of the Lake, after a descent of from seven hundred to a thousand feet in the course of a few miles. The previous higher level of the beds of many of these streams, is well marked by the potholes which have been left on the ledges, which once formed the river-beds, but are now many feet above the present level of the waters, and are bounded by perpendicular walls of rock, which once formed the sides of the channel.

The ravines and gorges through which most of the streams flow, after entering the hilly range near the Lake, are only a few feet in width at the top, and often appear to widen as they descend. Generally, however, they are almost, or quite perpendicular, especially where they cut through ridges of hard rock. In many cases, the gorges have evidently been cut out by means of boulders, which have been arrested in their descent at various points, and under the action of the stream, have excavated the lines of potholes just alluded to. These potholes gradually increased in size until they coalesced, their walls were broken down, and the channel thus deepened. Some of the gorges have, doubtless, been formed by fractures and dislocations of the rocks, during some part of the eruptive period, others by the disintegration of veins and dikes, but many of them owe their existence to potholes in the way mentioned.

Some of the streams enter the Lake through narrow gates, with perpendicular walls, while beyond the gate, landward, the river flows gently through a wide, flat bed, for half a mile or more, until the first high ridge is reached, where there is, invariably, a fall, or a series of cascades. The mouths of many of the streams are continually changing, partly in consequence of the detritus brought down from the high ridges during freshets, but principally from the action of the Lake during high winds, or when lashed by storms, the waves heaping up pebbles and boulders to the height of several feet, and forming, frequently, complete barriers across them, through which, however, their waters percolate into the Lake. These barriers remain until, after heavy rains in the highlands, they are swept away by the descending torrents. On a few of the rivers, at the distance of four or five miles from the Lake, the valleys become wider, and along some of the streams tracts of what might be called "bottom land" occur, rising with very gentle slopes to the base of the hills which environ them.

As before stated, these streams are often only a few feet in width, and ordinarily discharge but little water. The largest river explored did not exceed forty yards at the widest part seen, and this, two miles lower down, ran through a gorge only

three feet wide. Between Fond du Lac and Two Island River, they serve to drain but a limited portion of the country lying between Lake Superior and the highlands which divide its tributaries from those of Hudson's Bay; the Valleys of Cloquet, Big Whiteface, and St. Louis Rivers lying between the elevated ranges north of the Lake and the highlands spoken of, and draining a large extent of country. The descent into the Valley of the Cloquet is very little, in comparison with that on the lake side of the water-shed; and may be judged of from the elevation of its mouth above the level of Lake Superior, which is six hundred and thirty feet. The summit of the slope drained by the tributaries of the Lake, averages about twenty miles in distance, in a direct line, from the coast; varying from that to thirty miles at the most distant point; until, about the sources of Kawimbash River, it begins to increase in distance from the Lake (owing, principally, to the curvature of the lake-shore easterly, under the influence of the heavy east and west dikes, which intersect the northeasterly ones), and where it strikes the boundary line, it is fifty miles, in a direct line, from the mouth of Pigeon River.

Cloquet River, which heads near the sources of Kanokikopag River, pursues a southwest course, nearly parallel with the lake-shore, and empties into St. Louis River about sixteen miles northwest by west of the northwest corner of Fond du Lac Supérieure.

In the upper part of their course, as already mentioned, the rivers of the northwest shore, which often drain swamps and small lakes on the summit-level, flow through comparatively wide valleys, which contract as they descend into narrow ravines. Frequent slight rapids occur, after they leave the highlands. These gradually increase in frequency and descent, until, as the Lake is approached, they increase to cascades and falls, from twenty to forty feet in height; and, in some instances, several such cascades occur in the course of a few rods, making in all a fall of from sixty to a hundred and twenty feet, or more.

At the more elevated points examined towards the summit-levels, I invariably found the temperature of the streams greater than that of the atmosphere. On Two Island River, for instance, on the 14th of July, 1848, at an elevation of six hundred and forty-seven feet above the level of Lake Superior, the temperature of the atmosphere was 68° Fah., of the river 71°, and of a spring near the river bank 37°. The temperature of this spring cannot vary greatly from the mean annual temperature of the surrounding region, and differs but a few degrees from the constant temperature of Lake Superior.

All the hills, ridges, and valleys of the north shore, with the exceptions already named, are densely timbered. Among the trees are white cedar, birch, spruce, fir, pine, aspen, maple, elm, ash, and bass-wood; with a dense undergrowth, rendering it extremely difficult to traverse the woods, especially with delicate instruments, and interfering very materially with geological investigations.

SECTION II.

LOCAL DETAILS OF THE SECTIONS MADE IN THE RANGES NORTH OF LAKE SUPERIOR.

1. *Mission Creek.*—The sections already given of St. Louis and Black Rivers,* show the junction of the sandstone series with the underlying argillaceous and siliceous slates, upon which it rests unconformably. As these sections afford a key to much of the geology of the country, it is thought best to give another section, of the unaltered rocks near Fond du Lac, before proceeding to describe them in the more disturbed portions of the District, where they are associated with, and their relations obscured by, the numerous dikes and beds of trap found between Fond du Lac and Pigeon River.

Mission Creek is a small stream, which drains a portion of the country lying in the southern bend of St. Louis River, between the west end of Lake Superior and Grand Portage. It empties into the St. Louis at the village of Fond du Lac. The valley through which it runs before reaching the plain on which the village is situated, is deep and narrow, and bounded on the east side by the commencement of the high greenstone ridges which trend to the northeast, and on the west by deposits of drift, marl, and clay, such as overlie the sandstones, conglomerates, and slates of St. Louis River.

About three-fourths of a mile above the mouth of the creek, sandstone shows itself in the east bank of the creek, on the flank of the greenstone ridge, overlaid by marl and clay-beds† (1), just as they occur on the St. Louis River. Between forty and fifty feet above the water-level, the marl contains beds of pebbles, from eighteen inches to two feet thick, and in the upper part and on the surface, numerous large boulders occur.

The first exposure of sandstone (2) is about thirty feet in thickness, and dips southeast, at an angle of 10°. It is micaceous, and disposed to be shaly. Some of the beds are reddish gray, and others red, with marks of cross lamination. About two hundred yards further, red shale (3) comes up, eighteen feet thick, and containing bands of hard sand-rock, from four to eight inches in thickness. The bands are from eighteen inches to five feet apart. These shales are of a dark-red colour, but become bluish red on the planes of stratification, when exposed to the weather. In some places they look very much like indurated clay, but are gritty. The dip here is 20° southeast. Three hundred yards higher up the creek, the shale is underlaid by fifty-five feet of sandstone (4), in strata from six inches to four feet thick; and a short distance further on, the sandstone rests on twenty feet of thin, shaly rock (5). The upper part of the sandstone is reddish yellow, and resembles the thicker strata of St. Louis River. The lower part of the shales are bluish-coloured. They rest on a gray, pebbly, coarse grit (6), five or six feet thick, and

* See section (Pl. 2 N, Sect. 2), from the valley of St. Croix River, near the mouth of Upper Pinnette River, northerly, to Rainy Lake.

† See section on Mission Creek. (Pl. 2 N, Sect. 1.)

this grit is underlaid by thin beds of ripple-marked red sandstone (7). The pebbly beds show lines of cross-lamination. Next come up fifteen feet of red shales (8), resting on a thin bed of very hard, compact yellow grit; and below the grit-bed are red shales again, with thin partings of blue clay. Beyond this point, the creek runs between banks of clay and red marl, which appear to have slid from the upper part of the hills, and conceal the underlying rocks for the distance of nearly two miles, when argillaceous slate is exposed for a short distance. This was the last rock seen on the creek, and resembles that found at the Lower Falls of St. Louis River. Between the last exposure of red shales and the clay slate, the bed of the creek contains many very large angular fragments of greenstone, quartzite, and altered slate, which appear to have been derived from the high ridge east of the creek. (No. 436.)

The top of this ridge is composed of greenstone (No. 432, 433), and is six hundred and ninety-one feet above the level of St. Louis River at Fond du Lac. On the side of the ridge next St. Louis River, the greenstone (No. 434) passes into a rock somewhat resembling quartz rock, which is jointed, but does not appear to be stratified. There does not seem to be any line of demarcation between these varieties of greenstone. In descending the ridge in the direction of Fond du Lac, two hundred and thirty feet below the summit, beds of No. 435 crop out, and show themselves at various points, nearly to the base of the hill. It is probably a metamorphosed sedimentary rock, and the equivalent of some of the beds on Kinechigakwag Creek. This rock was also seen at several other points on the southeast side of the ridge which bounds the north shore of St. Louis River in the direction of the Lake. The beds are of great thickness, and often resemble quartz rock, such as was met with in the neighbourhood of Grand Portage Bay.

2. *Kinechigakwag Creek.*—This is the first stream emptying into the north shore of Lake Superior, east of the long point which separates St. Louis River from the Lake at its west end, for the distance of about six miles. At the junction of this point with the main land, a portage-path starts, which leads to Cloquet River, and is occasionally used by the Indians for the transportation of light canoes to that stream. At the summit of the ridge beyond the place where this path crosses Kinechigakwag Creek, the following Section begins.*

The ascent from the Lake up to the top of the first ridge, which is five hundred and thirty-two feet above the lake-level, is somewhat gradual. There is then a slight descent for several hundred yards, when the country rises gradually up to an elevation of five hundred and sixty-four feet, and then descends fifty-nine feet into the valley of the creek. The ascent to the top of the second ridge is very gentle. It is composed of greenstone, like that near Fond du Lac, of which it is a continuation, and bears northeast and southwest. The highest point measured was seven hundred and sixty-one feet above the Lake. These ridges, with the intervening valleys, are covered with a good soil, and bear a heavy growth of sugar maples, from which the Indians of the vicinity manufacture a great deal of sugar.

* See Section from the mouth of Kinechigakwag Creek towards Cloquet River. (Pl. 2 N, Sect. 3.)

The general aspect of the country is very much like that on the Grand Portage of St. Louis River.

The greenstone (No. 416) was the only rock seen from the culmination of the ridge to the valley of the creek. It is the first rock exposed in the bed of Kinechigakwag, where it is fine-grained, grayish-coloured, and contains occasional crystals of felspar disseminated through some portions of it. It is jointed, and as you recede further from the centre of the ridge, becomes bedded. The beds dip east-northeast, at an angle of 20°. About two hundred and seventy-five yards below where the portage crosses, there is a fall of sixty feet, in a series of cascades. Here the rock becomes finer-grained and slaty (No. 417), some of the beds resembling basalt very much in general appearance. The northeasterly dip still prevails.

One hundred yards below the falls, a thinly-bedded slaty greenstone (No. 418), comes in. Some of the beds resemble quartz-rock, while others, in consequence of the presence of hornblende in grains, much of which is arranged in parallel lines, have the aspect of a hornblendic gneiss. In the mass, this rock resembles very much the greenstone against which it abuts, where they come together high up the ridge, and also No. 417, which overlies it; but as it recedes further and further from the axis of the ridge, it gradually changes, until it presents the ordinary appearance of a metamorphosed sandstone, approaching very nearly to some of the beds on St. Louis River and Mission Creek, which are entirely unchanged by igneous intrusions.

Descending two hundred and fifty yards lower down, a metamorphosed siliceous shale (No. 419) is found beneath No. 418. It is very compact, has a conchoidal fracture, and is somewhat gritty to the feel. A few spots of a greenish-coloured mineral, probably epidote, are scattered through it. It resembles the metamorphosed shales of Hat Point, below Grand Portage Bay, and is intercalated with beds of schistose quartz-rock. Just below this point, the creek is crossed by a dike of No. 419, about thirty feet in width. It is the centre of the first ridge mentioned in ascending from the Lake. It forms an anticlinal axis, and on the lake side, the dip of the bedded rocks is changed to the southeast. No. 418 is the first rock met with in descending the creek below the dike.

Continuing to descend, No. 421 is found in contact with and resting on No. 418. It is an earthy-looking, siliceous rock, highly charged with chlorite, and contains small segregations of red felspar, which give the prevailing tint to the beds. It is difficult to decide on the exact nature of this rock, but from the best examination I was able to give it, I came to the conclusion that it is a metamorphosed sedimentary rock, similar in character to the metamorphosed shales of the regions about Baptism, Manitobimitagico, and Wisacodé Rivers. The siliceo-argillaceous shales, as well as the shaly sandstones, of this neighbourhood, contain numerous grains of felspar; and these, under the modifying influence of the numerous trap dikes which intersect the rock in question, were probably segregated, so as to give it a porphyritic structure, and more of a felspathic appearance than the rocks about here ordinarily present.

For the distance of half a mile below this, the banks of the creek are composed of clay and marl beds, which conceal the rocks.

The first rock which emerges from beneath the red clay, is a dike of No. 422, which is a continuation of one of the dikes seen on the Lake shore. In immediate contact with this dike, on the lower side, is a rock which resembles some of the altered siliceous shales in colour and general appearance, as well as some of the more laminated varieties of the metamorphosed sandstone, before described. It more nearly resembles, however, the slaty greenstones higher up the creek. Resting on this last rock, is a dark-coloured, metamorphosed clay slate (No. 424), traversed by a trap dike. In near contact with the dike, it assumes a trappous appearance. This rock is so full of joints, which separate when it is struck with the hammer, that it is exceedingly difficult to obtain a fresh fracture. It resembles most of the metamorphosed clay slates found in contact with trap dikes at other places. It continues to form the bed of the stream for several hundred yards, and does not differ essentially in its characteristics at any points, except near the dike, where it is somewhat brecciated. Traces of earthy green carbonate of copper were discovered in this rock, near its junction with the dike.

The beds which overlie those last named, again present the appearance of slaty greenstone (No. 425). They are, however, undoubtedly sedimentary. Overlying these beds is a bed of porphyritic greenstone (No. 426). It dips to the southeast, at an angle of 11°, and forms the bed of the stream for the distance of a quarter of a mile, with occasional exposures of No. 425, above it as well as below it, at the points of the small ridges which come up to the creek, when it finally disappears, and the upper beds of No. 425 continue to form the channel to within four hundred yards of the Lake shore. At the point mentioned, the sedimentary rocks are traversed by a narrow trap dike (No. 427), which forms a low ridge in its course, trending to the north. Below this dike, No. 425 continues to the Lake shore, where it is covered by a few feet of red clay. As the Lake is approached, some of the beds become brecciated and amygdaloidal, the cells being filled with epidote, chlorite, and some zeolites (No. 437). On the lake-shore, a short distance above the mouth of the creek, the porphyritic greenstone, No. 426, is found underlying No. 425. The prevailing dip of the rocks, from the mouth of the creek to the first high ridge, is to the southeast, at an angle of 10° to 12°. Beyond the first ridge, and up to the second one, the dip is northeast, varying to east-northeast; and on the lake-shore, at the point designated, the porphyritic greenstone dips 18° to the southeast.

Between the Entry Point and the mouth of Passabika River the metamorphosed sedimentary rocks are traversed by a number of trap dikes, differing both in composition and bearing. At the north end of the point, the metamorphosed rock dips east by north 14°. The first dike (No. 588), bearing north 30° east, is cut through in the second bay below, by one bearing north 45° east (No. 589). This last dike is behind the first one, at the point, and forms the ridge which gives the general dip to the sedimentary rocks. In its prolongation southwest, it comes to St. Louis River at the second expansion of that stream from the mouth, and is believed to underlie the islands which occur there in the line of bearing. No. 588 is entirely outside of this dike, and only to be seen at the second point down the Lake.

A narrow dike (No. 592), bearing north 14° west, cuts through the metamor-

phosed rock (No. 593), and forms in part the second point. In its course southerly, it forms, I believe, the long Entry Point, which is in its line of strike, although it is not discoverable in that part of its course, being covered with shingle and sand. Continued still further to the south, it would cross Black River at or near the Falls, where a dike of the same kind was found. The bedded rocks dip 18° southeast.

In the second bay there are five narrow dikes, all bearing nearly north and south, varying to 5° east, and of the same character as No. 592. They vary in width from three to twenty feet. A sixth narrow dike forms one side of the point between the second and third bays, the remainder being made by No. 591, several low exposures of which are seen in the last bay. The shore of the third bay is made by No. 594, and also the point between it and the fourth one. In this bay, the lake-shore is made by No. 595, which is much disturbed by the trap intrusions. At the point between the fourth and fifth bays, there is a dike bearing north 5° east, and in the fifth bay two dikes bearing north 5° west.

In the easterly part of this bay are low exposures of No. 597; most of the shore, however, is made by No. 595, in mural walls from ten to fifteen feet in height. The sixth bay, which is a small one, is made by metamorphosed rocks, which are much disturbed, and, in some instances, completely folded; the axes appearing to run north and south. This rock is traversed by a narrow dike of No. 592. At some points the sedimentary rock appears to be overlaid by a bed of trap. The next bay is the one in which is situated the mouth of Passabika River. At the point above the mouth of the river is a dike of No. 598, five feet in width, and causing a folding of the rock (No. 599), through which it protrudes, and which is here overlaid by a bed of trap, described in the river section.

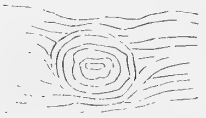
3. *Passabika River.*—The first rock of the series at the mouth of this river is a bedded trap (No. 597), overlying No. 400, on the west side of Passabika Bay. This last rock forms the left bank of the river for a short distance, where it is found to rest on a metamorphosed siliceo-calcareous shale (No. 401), dipping east, at an angle of 17°. The next rock below this is a breccia, composed mainly of fragments of altered sandstone and clay slate, and has the appearance of having been cemented under the influence of heat, which brought the materials into a state of incipient fusion. This rock continues up to the first fall, which is about a quarter of a mile above the mouth.

The water falls over a trap dike, bearing north 5° east. Just above this fall the river forks; and the section given from this point is on the west branch.

The first rock above the dike is the overlying trap (No. 597) seen at the lake-shore. About two hundred yards above the junction of the streams is No. 401, with about ten feet of compact, regularly-bedded, argillo-calcareous shale (No. 402), intervening between it and the trap-bed. No. 402 dips to the east at an angle of 14½°, and is highly metamorphosed and amygdaloidal. It becomes still more so as the stream is ascended, and finally gives place to a bed of reddish-gray, basaltic-looking rock (No. 403). Where this rock underlies the amygdaloid, there is a fall of forty feet in sixty yards, and the dip is to the east, at an angle of 20½°. A few yards higher up stream the dip changes to the southeast, and decreases to 6°; and

fifty yards further, the basaltic bed is overlaid by siliceo-argillaceous shale (No. 404). At some points, it is highly metamorphosed and compact, but on exposure to the weather exhibits its schistose structure. It appears to belong to the same beds as No. 401. Some of the beds resemble altered sandstone, while other beds approach quartzite.

Three hundred yards above the fall, this rock (No. 404) contains many large nests of minerals. These nests are from one to two feet in diameter, and contain, principally, calcareous spar and sulphate of barytes. The rock at these points seems to have been deposited around an original nucleus, as shown in the following figure.



Just beyond the place where these nests first show themselves, the strata become nearly vertical, as shown at (8) in the section,* and exhibit the most undoubted evidence, in their extraordinary contortions and bendings, of having been subjected to great lateral pressure (Nos. 405, 406). The shales and schists are very thinly laminated, some of the laminæ not being over an eighth of an inch thick.

The rocks gradually become more and more altered, until they are intersected by a dike of trap, sixty feet in width, bearing northeast by north and southwest by south. In the immediate vicinity of this dike, the schists are very compact, and disposed to assume a columnar structure. Here, there is a fall of several feet. Above the ridge formed by the dike, the schists are of a grayish colour, free from flexures, and dip to the southeast at an angle of 20°. Rather more than a quarter of a mile higher up, the stream is crossed by a dike of No. 408, six feet wide, and bearing east-southeast and west-northwest. The shaly rock (No. 409) in contact with the dike is highly metamorphosed. About seventy-five yards further on is another dike, thirty-two feet in width, and bearing north and south. Between these dikes, the shaly rocks are of a yellowish-red colour. Sixty yards higher up is still another dike, fourteen feet wide, and bearing north and south.

The space between these two last dikes is occupied by shales, so highly metamorphosed, as to lose almost entirely their distinctive character. The last-mentioned dike carries with it thin seams of calcareous spar and quartz.

In contact with it on the west side, the rock resembles very much in constitution that of the dike, but a short distance off, it resumes the character of a metamorphosed shale, and so continues until the beds become thicker, less shaly-looking, and finally compact. The lower beds (No. 410), are exceedingly hard and brittle, and break, without any regularity of fracture, into shapeless fragments. In some places it assumes a columnar structure, and resembles, in all its features, the quartzose porphyry of Wisacodé River, and other points further east. Its sedimentary character is conclusively shown by its containing rounded pebbles of other rocks. It is traversed by thin seams of calcareous spar.

* See Section on the West Fork of Passabika River, (Pl. 3 N, Sect. 5.)

Throughout the whole of this section, red marl and clay-beds are seen resting on the rocks, and over a great portion of it boulder-drift occurs. It is highly probable that the first two trap ridges met with in ascending the river are connected, both having flowed from the same great fissure, carrying with them the sedimentary rocks, and compressing them laterally, so as to produce the foldings and doublings of the strata, as shown in the following figure, as well as in the section.

In the bed of the river, where portions of the folded strata have been carried away by denudation, the thin laminæ of the shales stand up like knife-blades.

The east branch of Passabika River is much the largest, and exhibits in the first few miles some little variation in the distribution of the rocks, although the main features of its geology are precisely the same. The breccia continues for the distance of a quarter of a mile above the forks, where it is found to contain seams and nests of minerals (No. 412), among which are fluor-spar and epidote, and resembles, in this respect, a similar rock on Wisacodé River. A short distance above this, there is a fall of twenty-five feet over a bed of trap, which forms the channel of the river for a long distance, when it is crossed by a dike two and a half feet in width, carrying a vein of calcareous spar four inches wide, and bearing east 10° north, and west 10° south.

The next rock which comes up is like No. 399, this being found on the lake, shore below the mouth of this river, in the direction of the dip. It is in beds, from two to four feet thick, and dips southeast 18°. It continues to form the river-channel for half a mile, when it disappears beneath a bed of trap, probably the same which overlies it where it was first seen. This rock bears great resemblance to syenite, and might be mistaken for it in hand specimens. It belongs, however, to the same beds as No. 402 of the west branch of the river. At its junction with the overlying trap, mentioned above, there is a fall of ten feet, and above the fall the metamorphosed rock assumes more the character of No. 401. It is seen in the west bank of the river, six feet thick, and underlying the trap-bed. It is very amygdaloidal. Just above this fall is a spar vein, two and a half feet wide, with an east and west direction. It is accompanied by a narrow trap-dike, having the same strike. About one hundred and twenty yards above the dike is a ridge of greenstone (No. 413), which crosses the river, and makes a fall of thirty feet.

Immediately beyond this ridge, contorted shales, such as were seen on the west branch, occur, and form the bed and walls of the river for the distance of four hundred yards. These shales are traversed by numerous veins containing flinty quartz and various other minerals (No. 414). Some of these beds also contain numerous fucoidal impressions,* such as were found in the neighbourhood of Oginekau and Cut Face Rivers. (No. 415.)

The next rock met with is greenstone, forming a ridge and crossing the river in

* See Tab. I. C.

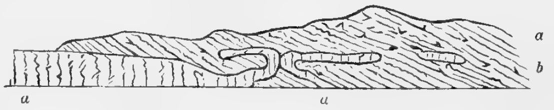
a northeasterly and southwesterly direction. It is very tough, weathers with a nodulated iron-shot crust, and resembles in all respects that seen at the mouth of Kawimbash River. After passing this ridge, No. 402 is found resting on the greenstone, and fifty yards further up it is overlaid by a bed of trap similar to that found at the mouth of the river.

The dip of the bedded rocks is changed to east-northeast, at an angle of 18°. These rocks are overlaid by clay, marl, and drift-beds. The clays and marls are bedded, and about thirty feet in thickness. The upper part, or that immediately under the drift, is yellowish-coloured, the remainder red. Over these beds is about eight feet of drift. Some of the boulders are remarkably large, and all well-worn and rounded. Above the drift is a deposit of red clayey marl, three feet thick, which is thinly laminated, and bears great resemblance to the beds overlying the drift on the Mississippi.

The point of rocks immediately below Passabika River shows, in the most satisfactory manner, proofs of ancient glacial action, in numerous grooves and scratches. Their course is south 46° west, and exactly at right angles with the dip or inclination of the rock on which they are found, showing, conclusively, that the action of the present lake ice could have had nothing to do with their production; as in that case, the ice would have descended the inclined plane to the Lake, and produced grooves having a southeast direction.

Another proof of their having been produced at a former period, and by other agents than those now engaged in modifying the lake-shore, is, that where the rock (No. 600) has been broken up by the action of present causes, so as to fall below the general level of the rock, the grooves and scratches disappear, and again reappear beyond the recently degraded places.

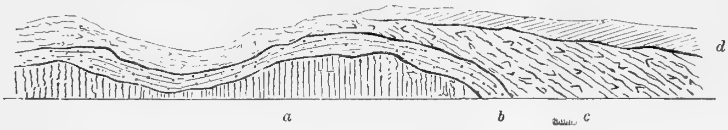
This rock (No. 600) forms the lake-shore as far as the middle of the second bay below the mouth of Passabika River, where it is overlaid by No. 595, which is traversed by a narrow dike of No. 601. The metamorphosed rock in contact with the dike (No. 602), is still more highly changed. It dips southeast 8°. A short distance further on is another dike, sixteen feet wide, with the same bearing, and accompanied by a spar vein six inches in width. These dikes hade slightly to the northwest. They are prismatic, and the joints horizontal. Near these dikes the metamorphosed rocks (No. 398) contain many large druses, filled with crystals of quartz and calcareous spar (No. 399). The last-mentioned dike, which seems to have an easterly course, does not cut entirely through the bedded rocks at some places, but appears rather to terminate in a number of strings, as shown in the annexed figure.



a, a, a, Dike. *b,* Metamorphosed rock, syenitic.

A little further on is a dike bearing north 5° east, traversing No. 595, which continues up the extreme eastern point of the bay, becoming, as it is removed further and further from the influence of the dike, decidedly shaly and thinly lami-

nated. At one point, a bed of trap, a foot thick, was found interstratified with it, the underlying shales being very amygdaloidal. Along this part of the coast there are great undulations in the stratified rocks, and the local dip varies from northwest to northeast and southeast, the general dip, however, being southeast, from 10° to 16°. The annexed figure represents one of the mural escarpments found here.



a, Trap. *b*, Amygdaloidal shales. *c*, Metamorphosed rock; syenitic. *d*, Clay and marl beds.

At the western point of the west bay, No. 603 shows itself, and also a narrow north 5° east dike. No. 603 disintegrates easily, and the joints are remarkably rusty. The metamorphosed rocks in contact with it are filled with zeolites. From the eastern point of the fourth bay, to the mouth of the Rivière des Français, the only rocks exposed are the metamorphosed shales, overlaid by No. 603, and dipping at an angle of about 21° to the southeast. The bottoms of the bays are composed of shingle, the rock exposures being confined principally to the points which separate them.

4. *Rivière des Français.*—At the mouth of this river there is an exposure of bedded trap (No. 603), overlying metamorphosed siliceous shale (No. 384). About one hundred and fifty yards from the Lake, there is a low uplift of greenstone, and at the junction of this rock with the metamorphosed shales, they contain nests of copper ore, and some grains of native copper. The rock is very amygdaloidal, and the ore seems to be disseminated through it, rather than concentrated in a vein. At the junction of the greenstone with the shales, there is a breccia, through which, also, the ore is distributed, with a great deal of laumonite and calcareous spar. There are no indications of a regular vein of ore.

The amygdaloid, which is of a dark reddish colour, and rather fine-grained and compact, continues to form the bed of the river for about two miles and a half, with the exception of a short distance, where it is replaced by a bed of trap (No. 383). Where it reappears, it is very amygdaloidal, and resembles No. 399. It dips east, at an angle of 11°. The junction of the shales with the overlying trap, is two hundred and thirty-two feet above the lake-level.

At the distance of two miles and a half from the lake-shore, the river is crossed by a heavy dike of greenstone, which forms an anticlinal axis, the summit of which is two hundred and eighty feet above the level of the Lake. The centre of the greenstone dike is dark-coloured and compact, while the flanks are coarse-grained and decompose somewhat easily. A vein of copper ore traverses this dike, and is exposed for some distance in the bed of the river. From the unfavourable circumstances in which it is exposed (being under water), no very reliable opinion can be given respecting its value. This much, however, can be said: it presents the best surface indications of any vein met with on the north shore. It is a quartz

vein (No. 381), with thin seams of calcareous spar, and small nests of hydrated brown oxide of iron.

The ascent to the summit of the ridge above this point is composed of metamorphosed shales, for about three hundred yards, where they are overlaid by the bedded trap. This last rock is heavily charged with iron, and weathers with a nodular, iron-shot surface, which, when freshly scaled, is very red.

On the northeast side of the axes, the amygdaloidal metamorphosed shales (Nos. 378, 379, 380) again appear, overlaid by No. 383. The cells are numerous, and filled with laumonite and other zeolites, and calcareous spar. About three hundred yards from the greenstone dike, the trap-bed disappears beneath clay and marl beds, and the shales are overlaid by a brecciated conglomerate (No. 377), which contains many rounded pebbles, but is, in the main, a breccia. In the lower part, it is quite as full of cells as the amygdaloid, and contains the same kinds of minerals. This rock is exposed in the bed of the stream, the banks being formed of red clay and marl.

The next rock met with in ascending the river, is metamorphosed siliceo-argillaceous slate, very hard, of a dark brown colour, and containing small siliceous nodules. The upper beds are of a deep red colour, and full of minute cells, containing a light, reddish-coloured mineral (undetermined), which gives to the rock a porphyritic appearance. Between this rock and the next one, in ascending order, is a bed of indurated clay, which becomes exceedingly porous when exposed to the weather. Above this come beds of metamorphosed sandstone. (Nos. 375, 376, 378, 379, 380.)

The dip of the rocks above the greenstone ridge which forms the anticlinal axis, is northwest, at an angle varying from 20° to 40°. On the lake side of the ridge the dip is southeast 11° to 12°.

In 1846, cabins were erected at the mouth of this creek, by the agent of a mining company, for the purpose of securing a pre-emption claim to the veins which occur here. When the effort made by the government, in 1847, to purchase these lands failed, the "location" was abandoned. There are also numerous indications of copper on a small creek which empties into the Lake, a short distance below the mouth of Rivière des Français. It was examined by Colonel Whittlesey in 1848, who brought from it several specimens of native copper, which he represented as of frequent occurrence in the amygdaloid. In his opinion, the veins met with on this creek are irregular, and of little or no value.

Just below the mouth of Rivière des Français, No. 603 is seen for a short distance, enveloping fragments of No. 605, and traversed by veins of No. 606. The exposure is low, and covered by marl and clay banks, fifteen feet in height, which continue, and form the shore, for a distance of three and a half or four miles. It is only at one or two points in this distance that the trap and underlying shale are to be seen. At the first point, there is a bed of trap intercalated with the shale. After turning into the next bay, No. 603 forms the shore until the large bay opens.

The large bay is bounded on its west side by a dike running north, 5° east (No. 607), and resembles, in all respects, No. 601, except that it is amygdaloidal, and the

joints are lined with heulandite. The shore of the large bay is composed of red clay and marl beds. At the point of the large bay, into the east side of which Carp River empties, No. 589 shows itself. The dike is large, and is cut directly across by the lake-shore, which exposes, lower down in the bay, its central portion, which rises rapidly from the shore, and forms a high ridge. About two-thirds the distance down the bay, No. 589 is traversed by a dike of No. 608, bearing north 15° west, and accompanied by a vein containing calcareous spar and zeolites.

In the bay above Knife Island, No. 588 forms tabular masses along shore, and continues on as far as the point opposite Knife Island. It appears to be bedded, and is traversed by numerous veins, which cross it at right angles to the line of bearing. In the centre of this bay is a small projecting point, made by a heavy dike of No. 607, bearing north 5° east. Further east, the bedded rocks dip to the southwest, but at Knife Island Point the dip is east. This point is from ten to twelve feet high, and is composed of No. 588, which also forms the island.

5. *Knife River.*—This is the *Mokoman Sibi* of the Chippewas, and is one of the largest streams between Two Island River and Fond du Lac Supérieure.

On the lake-shore, immediately below the mouth of this river, is an exposure of bedded rocks, very nearly resembling the ordinary metamorphosed sandstones of this region, but which, in consequence of some differences in their composition from that of common sandstone, as well as some differences of association, I have been led to believe were contemporaneous with the eruption of the dikes and bedded traps with which they are associated, and have therefore called them volcanic grits. The trap-dikes which have been erupted through these grits, produce quite as great a degree of metamorphosis in them as they do in the sandstones and other sedimentary rocks, and the changes thus produced add no little to the perplexity of the geology of the district in which they prevail, especially where continuity of the strata has been subsequently broken up by faults and upheavals.

Four beds of grit are exposed at the point designated (Nos. 325, 322, 323, 324), in the order in which they are named, No. 325 being the top rock. These beds overlie, a short distance up the river, a bed of basaltic rock (No. 354), which is seen in the banks for the distance of half a mile. It appears to be regularly bedded, and dips east by south at an angle of 11°. The next rock which comes up is a metamorphosed slate (No. 355), which, at some places, resembles the hornblendic slates of Pigeon River, but at other points is slightly altered, and shows with the greatest clearness the laminæ of deposition and the cleavage-joints. At other points again, it is changed to a hard, dark brownish-coloured rock, with occasional cells, containing *Thalite*,* and nodules of chalcedony. These rocks (Nos. 355, 356, 357, 358) probably alternate at this locality, as they were found to do at other places, as on Pigeon River, for example; but no positive evidence of such alternation was seen on this stream, the rocky banks of which are low, and the section not illustrated by exposures on the sides of the hills.

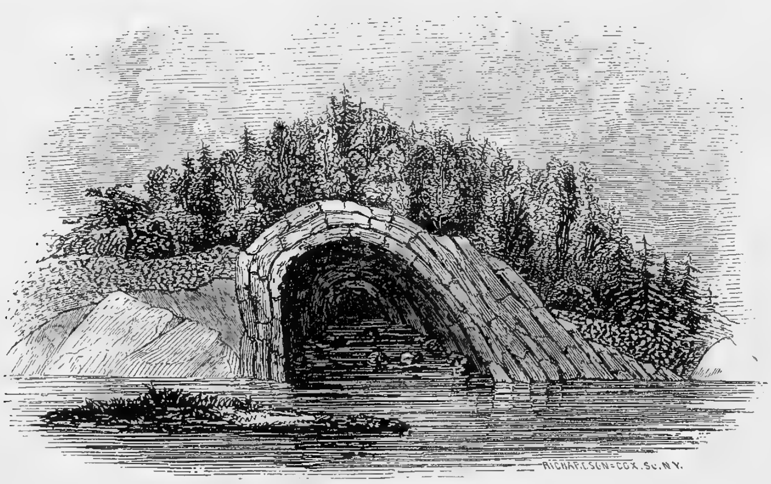
At the distance of a mile and a half from the Lake, the river is crossed by a dike

* The new mineral described by Dr. Owen.

of greenstone, about eighty feet in thickness, and making a fall. It bears northeast and southwest.

Three hundred yards above the falls, the metamorphosed slates are overlaid by a bed of volcanic grit (No. 359), very amygdaloidal, and containing small grains of native copper. It is only seen in low ledges at the margin of the river, the bed of which it continues to form for the distance of a mile, where it disappears under clay and marl beds, from fifty to a hundred and fifty feet in thickness. These deposits continue for another mile, when beds of metamorphosed sandstone (No. 361) come up, and show themselves for the distance of half a mile, dipping to the southeast at an angle of 11°. The exposure here is about two hundred and fifty feet thick. The rocks are again concealed by clay and marl beds for a mile and a half, when No. 361 again appears, with alternations of compact and fissile shales. Some of these shale-beds are highly metamorphosed, and assume a columnar structure. These rocks continue for half a mile, when the river is crossed by a dike of greenstone (No. 362), bearing northeast and southwest. The columnar beds of shale are amygdaloid, the cells being filled, generally, with laumonite. Before reaching the dike (No. 362), a quartz vein occurs, with native copper disseminated through the veinstone (No. 367).

Three hundred yards above the last-named dike, the river is crossed by another, bearing northeast and southwest, over which there is a fall of eight or ten feet. Between these last two dikes, the strata of metamorphosed sandstone and shales (No. 363) are bent upwards, and form an arch about twenty-five feet in height. The lower beds, which disintegrate easily, have been worn out by the action of the river, and a cavern of some depth has been formed under the arched rocks, as shown in the sketch below. On one side of the arch the dip is to the southeast; on the other, to the northwest.



ARCH OF METAMORPHOSED SANDSTONE AND SHALE.

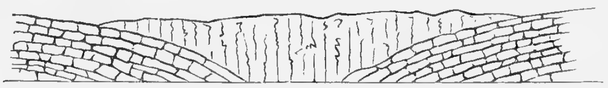
Beyond this point, for the distance of a mile, the river runs in the line of bearing along the side of the dike, which is the only rock exposed, as far as exploration was made.

Among the debris of this river, I saw numerous fragments of veinstone contain-

ing native copper, but was only able to discover the vein spoken of above. I can only say, in reference to the metalliferous indications in the rocks of this river, that I consider them sufficiently important to deserve the attention of the miner.

The point at the mouth of Knife River is made by No. 609. The bay below the mouth of the river is lined by an amygdaloid (No. 610), so full of cells that it fractures with the greatest ease. It extends along the whole of the bay, and bears north 30° east. It is more amygdaloidal at some points than others; and, as the first point is approached, the cells contain a great deal of thalite. At the point, the rock is red, like No. 599, and is bedded, though much disturbed. Just around the point is a heavy east and west dike (No. 611), the junction of which with the amygdaloid is well defined. After passing this dike, northerly, No. 610 again shows itself, and continues the whole extent of the bay, in low exposures, mostly covered with shingle.

In the succeeding small pocket is a bed resembling No. 603; and beyond this No. 610 is again seen, forming the small projecting points in the bottom of the bay. At some points it presents the appearance of having been partially, and at others, completely, fused, and injected with epidote. Further on, it becomes cavernous, and hollowed out into small pockets by the action of the Lake. The lower beds are very soft, and disintegrate easily; while the upper ones are hard and trappous. The strata are much waved, as shown in the following figure, and the dip varies



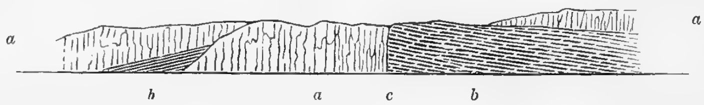
a. Shales. *b* *a* *b* *b, b.* Trap-beds.

much, both in degree and direction, but is generally to the southeast, at a low angle.

These rocks continue up to the second small stream below Knife River, where red clay banks make the shore nearly to the point below, when the rocks come in again. Here they are thin-bedded and regularly stratified. Just before reaching the point, they are separated by thin beds of trap, of which I noticed five at this place. They appear rather to be injections from a north 30° east dike, which subtends the arc of the bay, and shows itself just at the extreme point, bearing north 5° east, and resembling exactly Nos. 592 and 601. In the upper side of the deep bay below, there is an exposure of from forty-five to fifty feet of the rocks just mentioned, resting on a bed of No. 603. The remainder of the bay has a shingle beach. The long point which separates this from the next bay is composed of the same rocks, except that, at the extreme point, they are traversed by a north 5° east dike. The escarpment here is from thirty to forty feet in height. The next point, also, is made by No. 592, bearing north and south. Beyond this, the lower rock is soft, and weathers into caverns. It is red, thinly laminated, and some of the beds look very much like baked clay. Others show every evidence of cross-lamination. These beds are overlaid by a trappous-looking bed, from four to

eight feet thick, but which is probably a metamorphosed rock, and this again by a basaltic bed (No. 320). In the bottom of this bay is a low exposure of rock (No. 321), which seems to have been in a state of semi-fusion since its deposition, and subjected to partial flowing movements. It is a metamorphosed argillaceous shale, and contains small fragments of other rocks. It underlies the bed just noticed. The surface of this rock is planished in the direction of the dip, which I suppose to be the effect of present causes. From this point to the mouth of Kinewabik River, the shore is made by metamorphosed sedimentary rocks. Just above the mouth of Bitobig River, however, there is an uplift, and they are seen resting on a bed of trap. At the mouth of Kinewabik, they are also overlaid by a bed of No. 320.

Between Knife Island and Kinewabik River, several faults occur on the lake-shore, which, if not observed, would add very materially to the apparent thickness of these deposits. The following section shows one of these faults.



a, a, a. Trap beds. *b.* Metamorphosed shales. *c.* Fault.

The beds of shaly rock vary from four to twelve feet in thickness, and are sometimes separated by layers of a harder and more compact rock (No. 318), which resembles the sand-rock beds intercalated with the shales at other places. These rocks are generally capped by a bed of trap. (No. 319.)

6. *Kinewabik River.*—This stream was examined to the distance of four miles above its mouth. For the first three and a half miles, it runs nearly south, and for the last half mile, southeast by east. About three miles above the mouth, it forks. The west fork only was examined.

The first rocks met with in ascending the river, are metamorphosed, siliceous, and argillaceous shales (No. 346), alternating with thin beds of basaltic rock (No. 347). I estimated these beds to be four hundred feet in thickness. A mile and a half from the Lake, the shales present the characteristics of slaty greenstone (No. 348), and resemble precisely those of Kinechigakwag Creek. Some of the beds are slightly conglomeritic, and others show fine lines of deposition with remarkable distinctness. The lower beds are somewhat amygdaloidal. Above these rocks (which are about fifty feet thick), is a reddish-coloured, coarse-grained, metamorphosed sandstone, with thin beds of slaty greenstone (Nos. 348, 349), intercalated. The thickness of these last beds was estimated at one hundred feet. They rest against a greenstone dike, bearing northeast and southwest, which was the last rock seen *in situ* on the river.

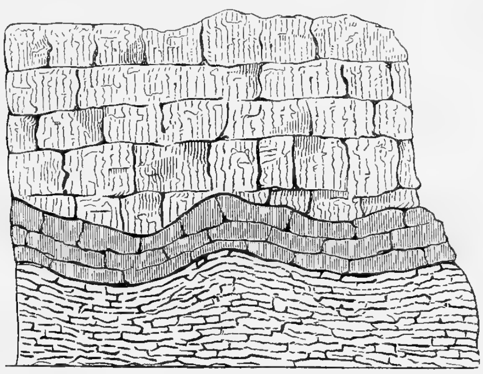
Beyond the dike, however, a great many fragments of unaltered argillaceous slate were seen in the river-bed, some of which were entirely too large and thin to have been transported any great distance. This leads to the conclusion, that beds of the unaltered slate, which is like that of St. Louis River, are in place at no dis-

tant point, but too far removed from the focus of volcanic action to have been affected by the causes which produced so great a change in the slate-beds in near proximity to the trap-dikes, and where they alternate with basaltic beds.

Some of the beds of No. 348, as before stated, are amygdaloidal. They contain large nodules, from one to three inches in diameter, formed by concentric layers of a siliceous material, and are filled with beautiful crystals of laumonite and calcareous spar. These nodules resemble, in all respects, except size, many of those occurring in the altered clay slates of Encampment Island River. The rock containing them on this stream, however, has been so changed by igneous action as to bear no resemblance, in general appearance, to that of Encampment Island River.

Below the mouth of Kinewabik River, the section along the lake-shore exhibits beds of shale, like those already described, with overlying trap-beds, until the first point is reached, where there is a heavy dike of greenstone (No. 613), which cuts through all the sedimentary beds, and near the contact alters the schistose rocks to No. 614.

The overlying and sedimentary rocks then continue along shore, and around the point to the next bay. At the point, however, a north-30°-east dike shows itself, and assumes a somewhat columnar form as the turn is made into Encampment Island Bay. In this bay, the overlying trap (No. 333) is about one hundred and twenty feet in thickness, and rests upon thirty-five feet of metamorphosed shales, with beds of a very compact rock intervening, as shown in the annexed section.



The bottom of this bay presents a shingle beach, with a heavy deposit of red clay and marl on the lower side, as far as the point opposite the island. For the last three miles of the shore, the dip of the bedded rocks is very irregular, varying from northwest to southeast.

7. *Encampment Island River.*—This river was explored to the distance of four miles, in a direct line from the Lake. At its mouth there is a deposit of drift and red marl, which continues for about a quarter of a mile up stream, when amygdaloid appears in the river-bed, dipping southwest 7°. This rock continues about two hundred yards, when a very hard, compact, fine-grained, siliceo-argilla-

ceous shale (No. 334) comes up, and extends for some distance up the river, making rapids. It is occasionally amygdaloidal, and, in some places, of a steel-gray colour, the latter colour prevailing as the river is ascended. This rock, in consequence of the river following the bearing of the ridge for some distance, forms the channel to a point estimated to be two miles from the Lake. About half way to this point, there is a fall of thirty feet over a dike of greenstone. (No. 337.) In contact with the dike are some beds of greenstone porphyry. (No. 336.) At this place there is an anticlinal axis. No. 338 is seen in the banks of the river overlying No. 334, and a little further on, an altered conglomerate makes its appearance, presenting, at some points, a brecciated aspect, but composed principally of rounded pebbles. The conglomerate and shale dip northwest 17°. About one hundred yards beyond this point, there is interposed between them and No. 334, a very soft, friable amygdaloid (No. 339), with occasional bands of a calcareous rock, bearing considerable resemblance to chert (No. 340) running through it in the plane of stratification. It is hard, compact, of a light yellow colour, and without cells. The cells of the amygdaloid are all compressed and elongated in one direction, and are filled with thalite and other minerals. This rock is very decomposable when exposed to the weather, degenerating into a bluish-coloured clay; and seems, in fact, to be nothing more than clay-beds, which have become indurated, and assumed the amygdaloidal character, under the influence of the neighbouring igneous rocks. The thickness of this rock, including the overlying conglomerate, as exposed in the river-banks, I estimated to be two hundred feet. Resting upon these rocks, at the point where the amygdaloid is best exposed, is a deposit of drift, marl, and red clay, about two hundred feet in thickness.

Beneath the amygdaloid, and emerging, as the river is ascended, is a metamorphosed shaly sandstone (No. 341), of a brick-red colour, with a trappous look, and an effort towards a columnar structure. It contains small cells filled with laumonite, and alternates with beds of a dark-gray altered slate, showing the lines of cleavage and of stratification with the greatest distinctness. It has a nearly vertical dip.

About three hundred and fifty yards beyond the point where the metamorphosed sandstone (No. 341) shows itself, is a greenstone uplift, producing a perpendicular fall of about twenty-five feet. At this place the slates are much contorted, and assume still more the appearance of trappean rocks. The greenstone (No. 343) is rather fine-grained, and contains seams of chlorite, occupying fissures, which appear to have been formed by some convulsion, long subsequent to the upheaval of the rock.

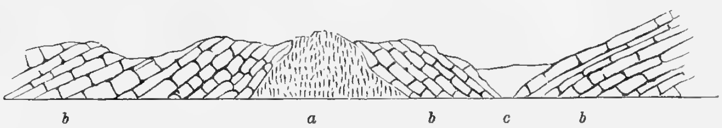
Two rods above the Falls, on the south side of the river, a vein five feet in width, composed principally of calcareous spar, with seams of quartz, is seen running northwest and southeast. It also contains traces of green carbonate of copper (No. 344).

A few yards above this is another fall, or rather a precipitous rapid. The river at this place is not over three feet in width, the stream running through a channel made in the course of a decomposed vein which traversed the greenstone. A

quarter of a mile above this fall, the greenstone, in the bearing of which the stream runs for that distance, disappears under a heavy deposit of clay, marl, and drift; and five hundred yards further up, the conglomerate shows itself again for the distance of three hundred yards, where it is overlaid by metamorphosed sandstone (No. 345), which forms the bed of the river for half a mile, and then dips beneath the clay and marl beds.

At the point where the exploration of this river ceased, the country is gently undulating, and timbered with pine, birch, hemlock, spruce, mountain ash, small maple, and cedar.

Encampment Island appears to be a fragment of the great greenstone dike (No. 613), seen at various points on the Lake shore, below the mouth of Kinewabik River. At the easterly end of the island, it is cut across by a north-and-south dike (No. 615), which appears at the opposite point on the mainland, where it has produced great disturbance in the bedded rocks, as shown in the following figure.

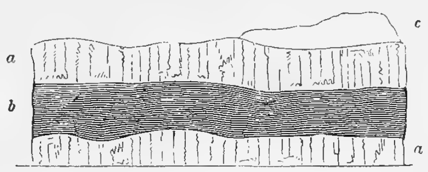


a. Greenstone. *b, b, b.* Metamorphosed beds. *c.* Clay and marl.

The rocks dip east and west, and on the east side the dip amounts to 41°. In the same bay, however, two hundred yards below the dike, the dip is to the west, at an angle of 9°. This continues for about three hundred yards, when the dip gradually changes until it is to the east. The dike producing the disturbances in the bedded rocks is not visible for some distance on the shore, but in the second bay below the island it is again seen (No. 333) above the water-level, overlaid by about sixty feet of metamorphosed rocks. In the bottom of this bay the north-45°-east dike (No. 613) contains immense fragments of a massive felspar rock* (No. 616). At the projecting point below this, there are some beds of trap between those of the metamorphosed rocks, which appear to be lateral injections from the dike. At one point the section consists, as here shown, in descending order, of,

a. Trap-beds.

b. Shaly-beds.



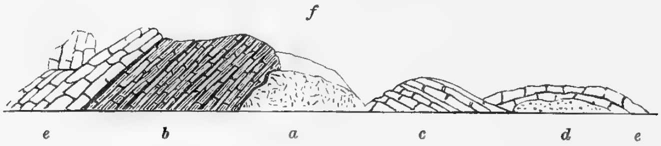
c. Red clay and marl.

a. Trap-beds.

1st, a bed of red clay and marl, overlying a bed of basaltic rock; 2d, thinly laminated siliceous shale (No. 316), very much altered in some places, and nearly unaltered in others. It contains organic impressions like those found on Passabika River, and also large waterworn fragments of other rocks. It weathers into caverns. 3d. A bed of basaltic rock, which has altered the shales near its contact with them into a hard, compact rock, with a hackly fracture, and a semi-columnar structure.

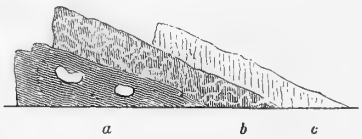
* An analysis of this rock is given elsewhere.

The same rocks continue through the next bay, the lower beds being amygdaloidal, and filled with zeolites. At the point below, and immediately after turning it, the beds are thin, and tilted up, as seen in the figure below.



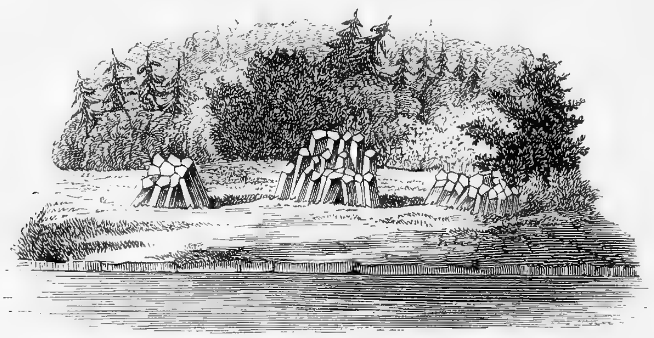
a. Greenstone. *b*. Metamorphosed shales. *c*. Volcanic grit. *d*. Amygdaloidal shale. *e*. Volcanic grit. *f*. Clay and marl.

Immediately after turning into the bay into which Goosebery River empties, a dike of No. 615 occurs, showing beautiful clusters of columns, and traversing what appears to be a north-30°-east dike. Just below Gooseberry River, large fragments of rounded rocks were seen embedded in the metamorphosed shaly rock, which is overlaid by the bed of compact columnar rock noticed at other places, and the whole capped by a basaltic bed, as shown in the annexed cut.



a. Metamorphosed shales. *b*. Compact beds, somewhat brecciated. *c*. Basaltic bed.

The basaltic bed forms regular columns, and at one point on the shore has disintegrated in such a manner as to leave three clusters of columns, several feet in height, standing on the metamorphosed beds which slope gently to the Lake.



CLUSTERS OF BASALTIC COLUMNS.

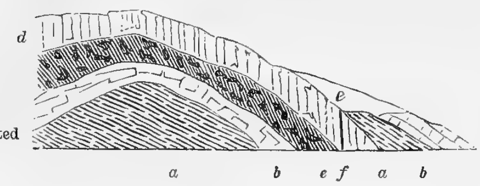
At one place in the same bay, a thin bed of basaltic rock was seen beneath the upper beds of the altered rocks. It was probably intercalated at the time of the overflow of the upper beds.

Near the mouth of Split Rock River, there is a section showing in ascending order, eight or nine feet of shale, twenty feet of basaltic rock, six feet of conglomerate, and about thirty feet of volcanic grit, all highly metamorphosed, and overlaid by a thick bed of basaltic trap. The shale and lower basaltic bed appear to be horizontal, while the sand-rock and trap-bed dip to the east. Section 3, on Plate 3, N, shows the succession of these strata: *a*, basaltic bed; *b*, volcanic grits; *c*, metamorphic shale. On the west side of the exposure the volcanic grit is also in

horizontal beds. The dip at this place seems to arise from the upper beds having been deposited on an irregular inclined surface, rather than from any disturbance since their deposition.

Below the mouth of Split Rock River there is a dike of greenstone, like No. 613, and bearing north 45° east. It is seen for some distance at the small projecting points along the shore, which follows its bearing, but the body of the rock is not cut across by the Lake. The rocks already described continue as far as the point above the mouth of Kanokikopag River, which, as well as the one below, is made by No. 613, bearing northeast and southwest.

8. *Kanokikopag River.*—The first rock exposed on this river is about a quarter of a mile from the mouth. It is a soft amygdaloidal shale (No. 288), overlaid by a more compact, thickly-bedded amygdaloid (No. 289). Both rocks dip to the east. The succeeding rock (No. 290) is still more compact, but exhibits, when exposed to the weather, a somewhat fragmentary appearance. The next rock seen is a columnar basalt (No. 291). It contains nests and strings of calcareous spar, and thin veins of argillaceous iron ore (No. 292). At some points the basalt is insinuated between the shaly and compact beds. Below it is a bed of No. 290, very much brecciated, and below that again, shaly rock, like No. 288. There is probably a fault near the first exposure of these rocks, by which the basaltic bed is made to dip, apparently, under the metamorphosed beds. It could not be seen, however, in consequence of a clay and marl deposit, which conceals the rocks at the place where it is believed to occur. As the lower fall is approached, all the beds, which have maintained a southeasterly dip, rise rapidly, and are, finally, bent downwards, and dip to the northwest, as shown in the following section: in which the basaltic bed, beyond the place where the clay deposit occurs, is seen occupying its true position with reference to the metamorphosed rocks.



a. Metamorphosed shales.
b. Compact amygdaloidal sand-rock.
c. Metamorphosed grit-beds, brecciated in the upper layers.
d. Columnar basalt.
e. Clay and marl beds.
f. Fault.

About a mile and a half from the Lake the first fall occurs, of five feet perpendicular, over a trap-dike, bearing north 30° east and south 30° west.

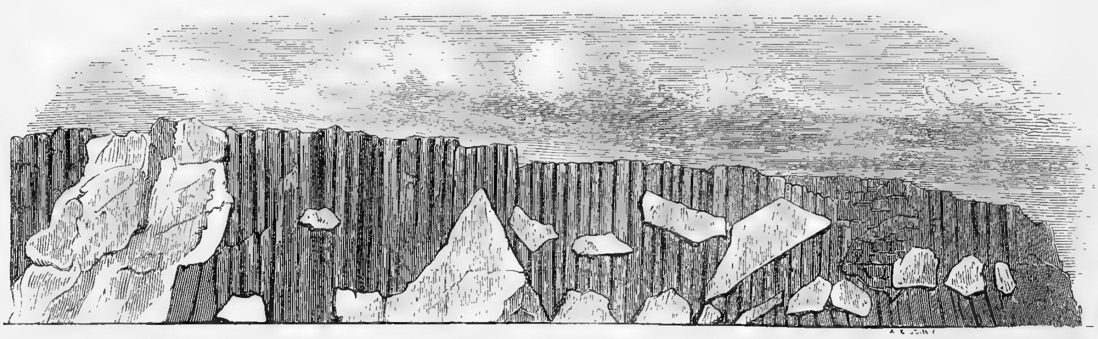
Above this dike the red shaly rocks (Nos. 288, 289) increase in thickness, and form a precipitous rapid, the top of which is fifty-five feet above the perpendicular fall just mentioned. The water falls through a narrow gap in the dike, only a few feet in width.

There is also a north-and-south dike here (No. 618), which cuts through all the rocks on the left side of the river just below the fall. On the right side of the river, the north-30°-east dike is divided, so as to enclose a large mass of No. 289. On the top of the ridge east of the fall, which is one hundred and twenty-nine feet high, No. 289 is associated with altered argillaceous slate (No. 619), and the same

rock is also seen tilted at a high angle near the intersection of the trap-dikes. Between this place and the second fall, which is a highly inclined plane, about twenty feet in height, the walls between which the river runs are composed of Nos. 288 and 289. At the second falls I saw no trap-dikes, the water cutting through the beds of No. 289. It is very probable, however, that there is a dike at no great distance above, as the metamorphosed rocks dip down stream at an increased angle. I did not ascend the river beyond this place.

At the Lower Falls, the changes produced in the sedimentary beds by the intrusive rocks, are remarkably interesting. No. 293 is from the north-30°-east dike, in immediate contact with the bedded rock; No. 294 is from the bedded rock in immediate contact with the dike; No. 295 is from the same beds, fifty yards from the dike; No. 296 is from the top of the hill east of the fall, and is the same as No. 291. On this hill, No. 304, which is more highly altered than some of the other beds, is associated with a hornblendic rock (No. 305), but in what manner I was unable to ascertain. Thin strings of greenstone (No. 297), and veins of No. 298, traverse the shaly rock near its junction with the dike. No. 299 is from the shaly bed above the falls, and contains organic impressions of the same kind as those found on Passabika and Encampment Island Rivers. No. 302 is from shaly beds on the lake-shore near the mouth of the river; and No. 303 from the greenstone dike already noticed as occurring above, just before reaching Kanokikopag Bay. The red beds of this river appear to occupy the same place in the series as the porphyritic beds (No. 591) seen near the Entry Point, and the Palisade Rocks, to be described hereafter.

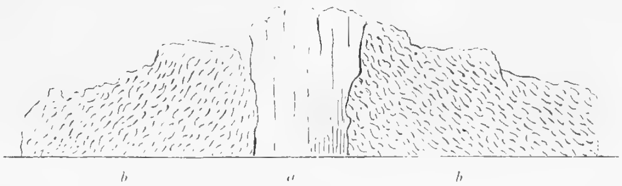
Immediately below the mouth of this river is a north-and-south dike, which appears to be the same as the one at the Lower Falls. Beyond this are some exposures of No. 620, with beds of altered shales and slates. Half a mile below the mouth of the river, a bed of trap overlies a soft amygdaloidal shale, of a brick-red colour, and containing many small nests of zeolites and other minerals. A quarter of a mile further on is an immense exposure of basaltic rock, which protrudes through beds of shale. The columns are perpendicular, and contain large angular masses of a felspar rock, as exhibited below.



MASSES OF FELSPAR INCLUDED IN BASALT.

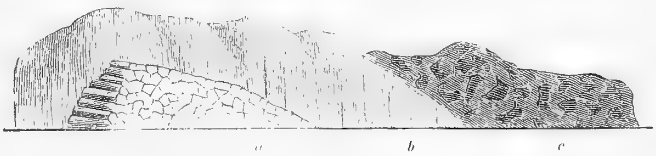
With the exception of the horizontal prisms seen on the west point of this bay, all the columns of basaltic rock in contact with the felspar rock are perpendicular.

At the point, the felspar rock seems to have been protruded through greenstone, as shown in the following figure.



a. Felspar rock. *b. b.* Greenstone.

The immense fragments contained in the trap rock, some of which would weigh many tons, do not, in any way, influence the direction of the columns. The felspar rock, which is very abundant in this neighbourhood, forming large domes, and the tops of the highest peaks, appears, at some localities, to graduate into syenite and greenstone, by the addition of the proper minerals. The horizontal prisms alluded to above, are shown in the annexed figure.

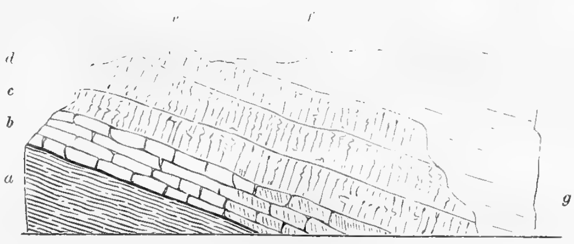


a. Prismatic dike. *b.* Felspar rock. *c.* Breccia.

The dike to which they belong, as it proceeds northeasterly, also contains large masses of felspar rock, as well as fragments of greenstone and siliceous porphyry, and where it is seen on the east side of the point, the columns are vertical.

The greatest confusion prevails in the bedded rocks at this place, and as far as the mouth of Little Cedar River. In the bay, above the point spoken of last, the following section occurs :

a. No. 299.
b. No. 300.
c. No. 301.
d. No. 302.
e. No. 303.



f. Metamorphosed siliceous shales.
g. Felspar and quartz rock.

1st, The lower beds are metamorphosed siliceous shale (No. 299); 2d, conglomerate, associated with beds of altered shaly sandstone (No. 300); 3d, a basaltic bed (No. 301); 4th, highly metamorphosed siliceous shale (No. 302); 5th, a bed of greenstone (No. 303); 6th, metamorphosed siliceous shale, in contact with felspar and quartz rock, and resembling the rock of the Palisades.

The eastern side of the bay, beyond the point where the great fragments occur embedded in the trap, is made by syenite (No. 622), and beyond this comes a heavy dike of No. 613, which seems to bear a little east of north. It is jointed, the joints being nearly perpendicular and nearly horizontal, and on weathered surfaces presents a singularly mottled appearance. The shore of the next bay is made, princi-

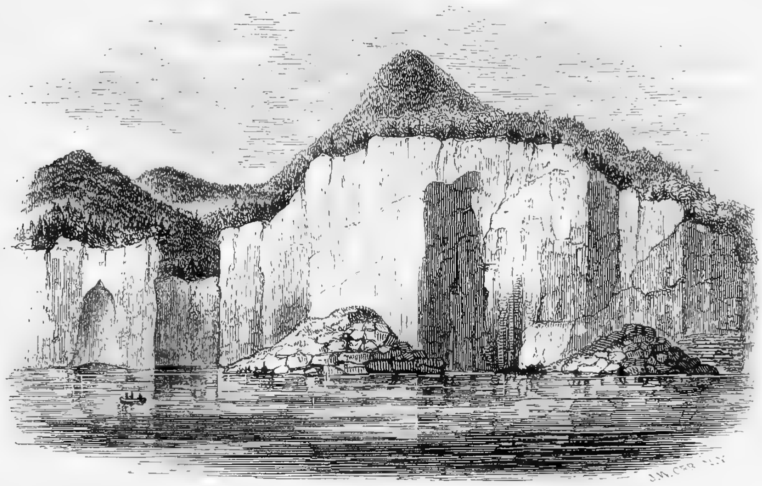
pally, by No. 613, and patches of shingle. In the bays, for a long distance above the Bay of Islands, this rock appears to bear east of north, and is seen at all the small points, and at the bottoms of the pockets, as far as the first island, which is composed of it. At several places it seems to be bedded, and to have overflowed the sedimentary rocks through which it was erupted. At the second point, above the mouth of Little Cedar River, No. 603 is seen, carrying with it, as before, huge embedded masses of felspar rock, and lining the shore of Cedar River Bay. The easterly point of the bay is made by No. 613. The islands between this point and the Great Palisades, with the exception of the one already noticed, are composed of No. 252.

Judging from the direction of the islands, and the line they make with one another, as well as with the shore and the Palisades, I set down the bearing of No. 252 at north 10° to 15° east. The shore opposite the islands is made by No. 603. In the bottom of the bay, above the Great Palisades, and between that and the islands, metamorphosed sedimentary rocks are seen underlying No. 603, which forms the small points that give so much irregularity to the shore here, and has embedded in it large fragments of felspar rock and of a greenish-coloured trap. At this place there are two, if not three large dikes, belonging to the different periods, and differing in mineral composition, yet having nearly the same bearing.

In the deep pocket, at the beginning of the Great Palisades, is a dike of No. 624, bearing north 45° W., traversing No. 625. The Palisade rock here overlies a very finely-laminated slaty rock, much altered by heat, and associated with a brecciated conglomerate (Nos. 627 and 628), which is interposed between the altered slate and No. 624. It is amygdaloidal, and presents the appearance of having been partially fused. Both the cementing material and the pebbles, which are rounded, are equally full of small cavities, most of them empty, but occasionally filled with partially decomposed zeolites and other minerals. The degree of fusion to which the rock has been subjected was so great as to produce a very complete blending of the pebbles; still the difference in degree of fusibility of the various rocks from which they were derived, as well as the differences of composition and colour, serve to mark its regular conglomeritic structure with the utmost distinctness and certainty. At this exposure the conglomerate is about forty feet thick, exceedingly rough and irregular in fracture, soft in some places and hard and brittle in others. It is traversed by veins of quartz, calcareous spar, and oxide of iron; all thin, and seeming rather to fill joints. Parts of the rock resemble very much the amygdaloid, underlying the basaltic trap before spoken of; and this is especially the case at its junction with the Palisade rock, which, as before stated, rests upon it.

The Palisade rock (Nos. 250, 251), specimens of which were taken from the bottom and top, present, essentially, the same characters throughout. It is generally of a brick-red colour, very hard, with a sharp, irregular fracture, and contains numerous small crystals of quartz, and many of decomposing felspar. Great numbers of minute quartz veins also traverse the rock, crossing each other in all directions, and producing a very beautiful reticulated structure. The following sketch, by Major Richard Owen, presents a very accurate representation of its appearance, as seen from the Lake. This rock rises from the margin of the Lake to the height of over three hundred feet, presenting perpendicular columns from sixty

to one hundred and ninety-two feet high, and from one to six feet in diameter. At other points, where the underlying rock dips east-southeast 15° to 19°, the columns incline toward the east at a corresponding angle. It is almost entirely



GREAT PALISADES.

detached from the mainland by a ravine, through which Palisade Creek comes from the westward. On the lake side, as before stated, it rises perpendicularly to the height of nearly two hundred feet in some places, and at the lowest point is not less than sixty feet above the water-level. On the land side, the rocks are quite as high, but may be ascended with difficulty at one or two places, by the aid of the small pines and firs which have taken root in the crevices. The highest point is near the west end.

From the top of this rock a magnificent view was afforded of the Apostle Islands, about thirty miles distant; and the outline of the high ranges south of the Lake, from the Porcupine Mountains to Fond du Lac, was distinctly visible. The outline of the hills on the north shore, as seen from the top of the Great Palisades, is well exhibited on Plate 1, N, 9. In the construction of this view, the eye of the observer is supposed to be placed about three hundred feet in front of the rock, and about three hundred and twelve feet above the lake-level.

9. *Palisade Creek.*—This stream, which comes in behind the Great Palisades, is a mere rivulet, but exhibits in the first two miles a very good section,* the beds of which occur in the following order:—

1. The rock forming the Palisades (No. 251), resting on very finely-laminated beds of the same rock (No. 252).
2. Very fine-grained basaltic trap (No. 253), which comes from under the Palisades, and crosses the creek, bearing northeast.
3. Brecciated beds (Nos. 254, 255), composed, principally, of fragments of red sandstone.
4. Basaltic rock (No. 256), apparently intercalated with beds of highly-metamorphosed sandstone.
5. Basaltic rock.

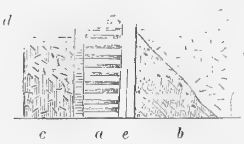
* Sect. 4, Pl. 3, N.

The upper basaltic bed (No. 256) seen on this stream appears to be the same as the bed seen in the bay above the Great Palisades (No. 258), underlying the brecciated conglomerate and shales at that place.

10. *Baptism River.**—The section on this river begins on the east side of the bay, where the rock (No. 223) rises, in the form of a palisade, to the height of one hundred and eighty-seven feet. It is columnar, the columns standing at right angles to the dip, which is east-southeast 17°. This is underlaid by eleven feet of tolerably compact amygdaloid, in beds from six to eighteen inches thick. Some of the beds resemble the basaltic rock seen at other points. Below this is a bed of shaly amygdaloid; and then come thirteen feet of No. 224, which appears to be made up of metamorphosed siliceous shale, with a basaltic bed intercalated. Underlying this are six feet of breccia, composed of fragments of the same rock, and beneath that again twenty-four feet of basaltic rock, with a thin seam of shale about the middle, dividing it into two beds. Then come eight feet of thin, decomposing, shaly amygdaloid, resting on seventy feet of No. 224, with some clay partings, dividing it into four beds. About the middle of these beds is one of amygdaloid (No. 225), which is hard and compact, and traversed by veins (No. 226) from four to seven inches in width. Beneath this is a bed of brecciated, shaly amygdaloid, overlying about twenty feet of No. 223; and below that another bed of shaly amygdaloid.

At this point the rocks are cut through by a prismatic dike (No. 228), eighteen feet wide, and bearing east and west. Between the sides of the dike and the rocks traversed by it are perpendicular joints, several inches wide, filled with calcareous spar, zeolites, and what appears to be decomposed chlorite. In near proximity to the dike, the metamorphosed shales (No. 227) become still more highly changed. The following diagram will serve to illustrate the position of the rocks near the dike.

a. Dike.
b. Shaly amygdaloid.
c. Metamorphosed shales, porphyritic.



d. Clay and marl.
e. Vein of calcite and zeolite.
f. Vein of decomposing chlorite.

On the south side of the dike, the metamorphosed slate, which resembles, in all respects, that seen in Kagitshiwaninawak River, except in being much more altered, is very much bent and contorted by the intrusion of the dike, like the shales of Passabika River, to which the rock here bears a general resemblance, although at some points it is most like No. 252. The intrusion of the dike at this place has caused a fault, in consequence of which these beds are not seen on the north side in contact with the trap.

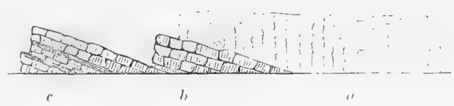
These metamorphosed slates form the walls, or gate, through which the river enters the lake. They are perpendicular, and about twenty feet high; and from them the Indian name of the stream is derived—Asinpatakitasibi, or River of Standing Rocks.

* Sect. 2, Pl. 1, N

After entering the mouth of the river, the first rock seen is about one hundred yards from the gate. It is traversed by spar veins from eight to twelve inches wide. The next rock (No. 230), soon comes up, making a high ridge, and containing fragments of metamorphosed sandstone (No. 231). On the upper side of the ridge are beds of No. 231 resting on the greenstone, and dipping northwesterly. The succeeding rocks (Nos. 232, 233, 234), are altered slates and shales. Some of the beds have yellow spots and stripes, and resemble the thinly-laminated, metamorphosed bed at the lake-shore. These rocks are succeeded by a ridge of very compact basaltic rock (No. 235); and two hundred yards further on, unaltered red sandstone makes its appearance (Nos. 236, 237). Some of the beds are very fine-grained and thinly laminated, while others are pebbly, and separated by beds of conglomerate, the pebbles being almost entirely of sandstone. Between No. 235 and the unaltered sedimentary rocks, is a shaly rock, partially altered, conglomeritic, and brecciated. This breccia, like that seen at several other places, seems to have been formed by the breaking up of beds of the ordinary red sandstone conglomerate and associated schistose beds.

The dip on the lake side of the anticlinal axis is to the southeast, at an angle varying from 5° to 75°, and on the opposite side to the northwest, at a low angle. In the bay of Baptism River, about two hundred yards below the mouth of that stream, is a dike which cuts through the bedded rocks, and bears north 65° west. The shores of the next bay below are composed of No. 250, and the bottom of the long, irregular bay which comes next, is bounded by the softer metamorphosed shales and bedded trap, with small points of No. 250, which jut out and form shallow pockets. The annexed cut represents a section of one of the small bays.

a. Metamorphosed shales,—columnar.
b. Beds of basaltic rock.



c. Basaltic beds intercalated with shales.

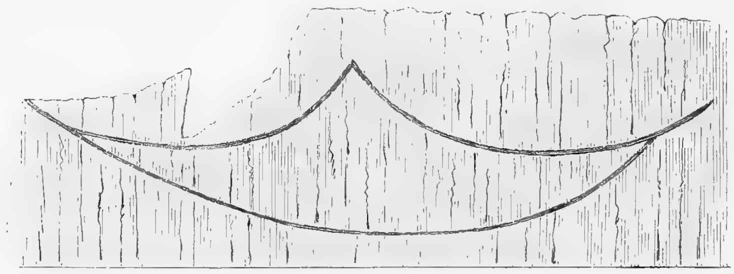
The lower shaly rock decomposes easily when subjected to the action of water, and occasionally forms long, narrow points, and lines of pillars, with aisles a few feet in width between them. They sometimes project into the Lake for the distance of a hundred yards or more, and with their cappings of small cedars and firs, present the most picturesque appearance imaginable.

The high ridges along this part of the coast sometimes approach to within two hundred yards of the bottoms of the bays; but, as a general rule, they begin to rise about a quarter of a mile from the Lake. They bear about north 30° east.

Immediately below the mouth of Waginokaning River, the rock (No. 629) resembles, in some respects, No. 603, but has a more irregular angular fracture, and the surface is jagged and pointed. It bears east and west at this place, and is disposed to become globular in the mass, at the same time that the structure is semi-columnar, as shown in the following diagram.

This rock (No. 629) forms the lake-shore for a long distance, and at several localities is seen resting on a bed of basaltic rock, beneath which is a bed of breccia. At the mouth of Waginokaning River, there is a fine exposure of basaltic rock, overlying amygdaloid. On the point which projects into the Lake, it has a true

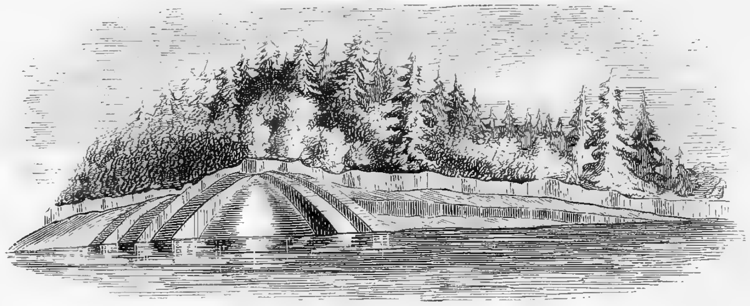
columnar structure, the columns being from eight to fifteen inches in diameter, and from four to six-sided, standing vertically, and with great regularity of outline. It contains occasional nodules of laumonite and other minerals. The amygdaloid at



this place does not differ from that described as occurring at other localities. The cells are numerous and large, and many of them are filled with thalite, either incrusting the sides of the cells, or in kidney-shaped nodules. Large nests of laumonite, in conjunction with calcareous spar, are also common. These beds also contain many thin veins of argillaceous iron ore, the sides of the veins being lined with stellular crystals of heulandite.

I did not examine the bed of the stream beyond the second ridge; the latter is three hundred and nineteen feet above the lake-level, and composed of a rock like that which I have considered, at other localities, to be a volcanic grit. In 1848, however, Colonel Whittlesey, who struck this river several miles above its mouth, brought specimens of slaty hornblende, which he found *in situ* three miles from the Lake. It may also be mentioned in connexion with this locality, that the amygdaloid in contact with the basalt, often assumes an imperfectly columnar structure.

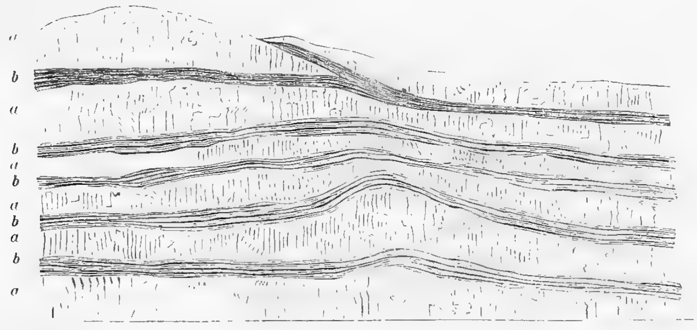
Below the mouth of Waginokaning River, the lake-shore is bounded by columnar rock, which rises in rounded, dome-like exposures for more than half a mile. One of these domes is represented in the following sketch. They rise from twenty to



thirty feet above the water-level, and are surrounded by concentric layers of rock on every side, like the coats of an onion. Over this rock is a bed of basaltic trap, from three to fifteen feet in thickness, which seems to have been deposited since the underlying rock began to disintegrate.

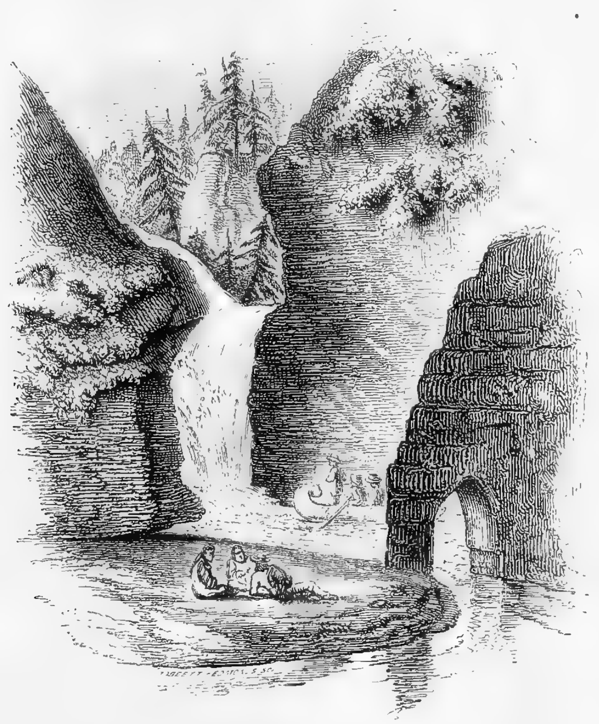
The bedded traps in this neighbourhood appear to have been deposited at different periods of activity, with brief intervals of rest between them. At one point on the lake-shore, about a mile above the mouth of Manidowish River, is an

escarpment, showing six beds, with thin partings of ferruginous clay and shale between them, as represented by the annexed cut.



The dip of these beds is to the southeast.

11. *Manidowish River.*—At the mouth of this river, a hard, compact amygdaloid, containing small, siliceous nodules, and veins of laumonite and calcareous spar, forms

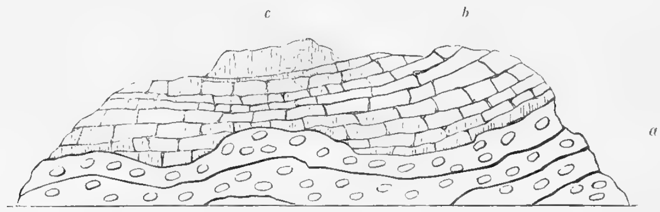


GORGE, FALL, AND ARCH OF MANIDOWISH RIVER.

the lower part of the bluff, and is overlaid by conglomerate, which, although brecciated, contains many large, rounded pebbles of altered sandstone, amygdaloid, and a coarse jaspoid rock. The amygdaloid and conglomerate seem to alternate, as they become

more fully developed in the gorge, a short distance up the river, some of the beds presenting the amygdaloidal form, others the characteristics of the conglomerate. This is particularly well seen between the first and second falls of the river. The lower falls are about forty yards further up, with several small cascades between them. The water falls in that distance seventy-eight feet. At the second falls, the lower beds disintegrate with great facility. At the mouth of the river, an arch has been cut through the amygdaloidal beds, on the left side, through which the river enters the Lake, when its mouth becomes blocked up by sand and gravel during the prevalence of storms, as shown by the sketch on page 367, taken by Dr. Owen, in 1848.

Between the mouth and the first fall, the conglomerate is overlaid by twenty-five feet of grayish-coloured metamorphosed rock, and above that is a bed of trap, as shown in the following cut. The water falls twenty feet through a gorge eight feet



a. Conglomerate.
b. Metamorphosed sedimentary beds.
c. Basaltic bed.

in width. The metamorphosed rock gradually assumes a more compact character in the ascending layers, and finally graduates into an amygdaloid like the one underlying the conglomerate.

One mile up the river, a bed of amygdaloid is overlaid by a very hard, compact rock (No. 211), which presents at some points a semi-columnar structure and a trappous appearance. It is, however, a metamorphosed siliceo-argillaceous shale, and seems to have some intercalated beds of argillaceous sand-rock. About two miles up the river, it forms narrow perpendicular dalles, the walls of which are forty feet in height. I estimated these shales to be two hundred and fifty feet in thickness. They are in layers from half an inch to two inches thick, generally of a red colour, but in some places gray; the upper part weathering easily, but becoming more compact in the lower beds, which are of a dark purplish colour, and amygdaloidal.

Between the brecciated conglomerate and the metamorphosed shale, is a bed of coarse, dark-red trap, from fifteen to twenty feet thick, and conforming to the general dip of the rocks already named, which is southeast by south, at an angle of from 8° to 10°. Above this point, and beneath the trap, there occurs from two hundred and fifty to three hundred feet of a rock such as has usually been described under the name of volcanic breccia (No. 212). At the junction of this rock with a dike which crosses it, it presents every evidence of fusion, and resembles, in both internal and external characters, some of the breccias from extinct volcanoes of Italy and France. It is evident, however, that the great mass of material which enters into its composition, has been derived from sedimentary rocks, through which the molten trap has been forced, breaking them up, and reducing the fragments to a semi-fluid state. Beyond the dike, for the distance of a mile and a half, this rock is exposed

in the river-bed, where it is found to rest on an uplift of greenstone (No. 214). I did not explore the river beyond this point. Colonel Whittlesey, however, continued the exploration several miles further up. He informed me, on his return, that beyond the greenstone, he met with slaty hornblende, which he estimated at one thousand feet in thickness. He followed the stream, which is a succession of rapids, to a point which he supposed to be fourteen miles, in a direct line, from the lake-shore. The highest ridge measured by me on this river, was seven hundred and twenty-two feet above the level of the Lake. The strike of the ridges which cross the river is north by east and south by west.

A short distance below the mouth of Manidowish River, the brecciated conglomerate is thirty feet thick, and contains some immensely large fragments. It is overlaid by a bed of No. 629, which rock is found at various points in the next two miles, overlying a very ferruginous rock, which sometimes has the characteristics of an ochre. It presents the appearance of a minutely-divided sedimentary deposit, and is distinctly bedded. It is amygdaloidal in some places, compact in others, and contains small fragments of trap. In contact with the trap beds and dikes, it is highly indurated.

12. *Kagitshiwaninawak River.*—A section of the rocks on this river, for the first three miles,* shows as follows, in descending order :—

11. A bed of reddish-coloured trap, embedding large fragments of metamorphosed sandstone, from two to ten feet in diameter. It also contains fragments of conglomerate and of the underlying shaly beds. Its general character is basaltic.

10. Thin beds of hard grit, containing scales of mica and rounded grains of sand.

9. Conglomerate; containing fragments of a still older conglomerate. It has a shaly, ferruginous cement; and the pebbles, together with the large fragments, are all rounded.

8. Metamorphosed sandstone.

7. Metamorphosed slates.

6. Metamorphosed sandstone.

5. Amygdaloidal shaly-beds.

4. Ferruginous grits.

3. Shaly-beds; amygdaloidal.

2. Volcanic grit-beds, containing a few amygdules.

1. Volcanic grit; amygdaloidal.

The beach at the mouth of this river is sandy, and lined with boulders, banked up to the height of ten feet above the lake-level. On the southeast side of the river, the hill next the Lake is composed of drift, red marl, and clay, and rises to the height of one hundred and sixty feet. This is underlaid by the trap bed, and metamorphosed sandstone, which rises to the summit of the next ridge, which is four hundred and eighty-four feet above the Lake. The bed of the river, on the northern side of this ridge, is one hundred and eighteen feet below the summit, and is composed of metamorphosed sandstone, which gradually assumes an amygdaloidal

* See Section on Kagitshiwaninawak River. Plate 1 N, Sec. 8.

character in the lower beds. One hundred and ninety-two feet below the top of the ridge, the brecciated conglomerate is intercalated with beds of siliceous shale, and underlaid by altered sandstone. The conglomerate is seventy-one feet thick. At the points where the irregular shape of the pebbles and fragments, and the paucity of cementing material, allowed a cavity to remain, the sides are incrusted with zeolites and calcite.

The metamorphosed slate on this stream is of a light red colour, variegated with exceedingly thin laminæ of blue and orange. The lines of deposition are most distinctly marked, over fifty of them occurring sometimes in the depth of an inch. Large yellow spots and stripes are also of frequent occurrence; the spots, which are round or oval, penetrating the bed perpendicularly, like those so common in some of the red sandstone beds of the south shore of the Lake. Some of the beds contain segregations of quartz, and thin veins of thalite.

The dip of these beds is southeast, varying to south-southeast, at an angle of from 18° to 21°.

Nos. 8, 9, 10, and 11 of the above section are not to be seen on the stream, but are a continuation of the section carried from the point where the rocks cease to be seen in descending the river, across the line of bearing, to the points which project into the Lake on either side of the bay, and where they are well exposed.

The point below the mouth of this river is formed by No. 630, bearing north 30° east. It continues to line the shore to the mouth of Cariboo River.

13. *Cariboo River.*—On the lake-shore, above the mouth of this river, the overlying trap contains immense rounded masses of basaltic rock, some of them as much as twenty feet in diameter, with concentric layers. In some of the mural walls these globiform masses have weathered out, leaving large round cavities. The difference, if any, between these masses and the rock in which they are contained, I am not prepared to state.

The section on Cariboo River,* in descending order, is as follows:—

1. Red clay and marl.
2. Basaltic rock.
3. Volcanic grit, with globular masses of basaltic rock interspersed through it.
4. Corrugated or wrinkled beds.
5. Volcanic grit—amygdaloidal.
6. Metamorphosed sandstone.
7. Metamorphosed sandstone—the lower beds pebbly.
8. Conglomerate—intercalated with shaly layers; very ferruginous; some of the rounded rocks are a foot in diameter.
9. Shales, with beds of conglomerate.
10. Basaltic rock.
11. Volcanic grit.
12. Amygdaloidal volcanic grit.

The general dip is to the southeast, varying to east-southeast, at an angle of from 10° to 19°.

* See Pl. 1, N, Sec. 7.

The general course of Cariboo River is south, and, as far as explored, is a succession of cascades, with perpendicular walls of rock on each side. The chasm through which it flows is from eight to twenty-five feet in width, and from sixty to eighty feet in depth. The bearing of the range is from northeast to southwest. After ascending the bluff at the mouth of the river, there is a very gradual rise for three-quarters of a mile, to the height of one hundred and forty-eight feet, where the first ridge begins, the summit of which is three hundred and thirty-four feet above the level of the Lake. Following up the stream, which flows in a gorge cut through this ridge and a spur of the succeeding one, for a mile and a quarter, No. 189 appears in the bed of the stream, at an elevation of three hundred and four feet. This rock, of which there is one hundred and twenty feet exposed at the falls, does not differ from similar beds at other places, except in being highly charged with carbonate of lime in some of the beds. The conglomerate exposure at the same place is eighty feet thick, with beds of siliceous shale intercalated, and resembles, in this respect, the conglomerates seen on Kagitshiwaninawak and Black Rivers, already described. The contained pebbles are, some of them, very large; and although many of them are angular, and give to the rock somewhat of a brecciated appearance, they are mostly rounded, and have a weathered aspect. Among them I noticed amygdaloid, slate, greenstone, and jasper. The paste in which they are embedded is calcareo-ferruginous, effervesces freely with acids, and contains a large percentage of iron.

Beneath the conglomerate is an altered clay-slate, the upper part of a steel-gray colour, and much indurated, but breaking in the lines of deposition as well as cleavage with facility. This rock gradually changes as it descends, and finally becomes metamorphosed into a dark reddish-coloured, jaspoid rock, extremely hard, with an irregular sharp fracture, and containing many small nodules of blood-red jasper. At the point where this section occurs, which is about two miles from the Lake, is a fall of one hundred and twenty feet, in three cascades, which exposes the contact of the different rocks in the most satisfactory manner. The wood engraving that forms the frontispiece to this Report, on page 208, from the pencil of Major R. Owen, represents the fall and escarpment of two hundred feet, through which Cariboo River descends to the Lake.

The principal rock on the lake-shore, between the mouths of Cariboo and Two Island Rivers, is No. 630; associated, however, at many points, with other beds. The bay into which Cariboo River empties has a shingle beach, covered with large boulders, except toward the west end, where there is an exposure of from five to six feet of amygdaloid; and then, for one hundred yards, an escarpment thirty feet high, where the amygdaloid is overlaid by No. 630. The same rocks are seen at the point between this and the next bay below, twenty feet in height. The second bay has a shingle beach, without any rock exposure. At the point below, however, the same rocks occur in an escarpment thirty feet high, and dipping to the southeast, at an angle varying from 17° to 28°. In the third bay there is an exposure of five feet of rock, and at one point there seems to be a basaltic bed underlying the amygdaloid. Back of this bay, at the distance of about three-quarters of a mile, the ridge through which the gorge on Cariboo River is cut, passes in its northeast-

erly course. At the next point there is thirty feet of rock, dipping southeast 19°. The lower beds are like No. 189, and are overlaid by a bed of basaltic rock. The fourth bay has a narrow beach, with a mural precipice back of it, from twenty-five to forty feet in height. At one point it shows the following section, in ascending order:—

	Feet.
1. Shaly amygdaloid, ...	2
2. Metamorphosed sandstone, ...	4
3. Shaly amygdaloid, ...	16
4. Metamorphosed sandstone, ...	7

These rocks all dip southeast, at an angle of 19°.

The point below is from fifteen to twenty-five feet high, and is composed of the same rocks, with numerous thin veins of calcite traversing them in the line of bearing. They continue up to the sixth bay, varying from ten to thirty feet in height. The point between the sixth and seventh bays is made by ten feet of No. 189. The seventh bay has mostly a shingle beach, but the same rock is seen in low exposures up to the point between the seventh and eighth bays, where there is a mural escarpment thirty feet in height. The beds are from five inches to three feet in thickness, and dip east-southeast, at an angle of 19°. These beds continue to the mouth of Two Island River, varying from fifteen to twenty-five feet in height.

14. *Two Island River* (*Nizhwakwindig Sibi*).—This stream, which appears on the maps to be the largest river of the north shore, between Fond du Lac Supérieure and Pigeon River, is, in fact, among the smallest, both in relative length and in the amount of water discharged by it. It was explored to the distance of about eleven miles from its mouth, following its meanders, and in a direct line from the lake-shore about seven miles. In this distance the fall is six hundred and fifty-five feet, and occurs, principally, in the first half of the distance named. The highest ridge met with measured seven hundred and twenty-six feet above the lake-level. The heights of the ridges between this one and the lake-shore, of which there are five, are, 5th ridge, six hundred and twenty-four feet; 4th ridge, four hundred and forty-six feet; 3d ridge, three hundred and seventy-nine feet; 2d ridge, one hundred and eighty-eight feet; and the 1st ridge, seventy-four feet.

Following the river-bed, the rocks are exposed for the distance of five miles. Beyond that, they are concealed by a few feet of drift, but are to be seen on the tops of the high ridges, and in the ravines cut down their slopes by occasional rivulets.

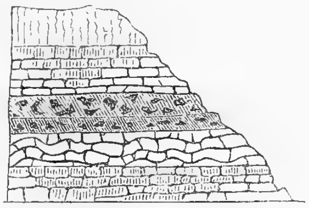
For the first four miles, the rock is a dark-red, coarse-grained amygdaloid, shaly and decomposing at some points, and alternating with beds of a firmer and more compact texture at others (Nos. 188, 189, 190). At several points greenstone was seen in the bed of the stream, and at the distance of four miles from the mouth is a large uplift, overlaid by No. 188. At the junction of the greenstone and amygdaloid, the overlying rock assumes a more trappous appearance, becoming harder,

darker-coloured, of a finer and more compact texture, and bearing no little resemblance to the metamorphosed sandstone of Black River. These beds contain nodules of chalcedony and agate.

On the tops of the highest ridges of this range, and overlying the great greenstone ridges, is a rock in all respects like the amygdaloid, except that it contains no amygdules; and the peculiar green mineral (thalite), so abundant in the cells of the amygdaloid, appears to be disseminated through it in small particles, giving to the rock an aspect of homogeneousness, and a very peculiar, rough, irregular fracture. It is red, coarse-grained, and, upon exposure, weathers with a grayish-coloured, nodular fracture. It is distinctly bedded, and conforms to the dip of the amygdaloid, which is east-southeast and southeast, from 18° to 19°.

In proceeding down the lake-shore from Two Island River to the Inaonani River, the rocks are exposed in detail for nearly the whole distance, consisting of beds of trap, volcanic grits, and metamorphosed sandstone. About two hundred yards above the mouth of Inaonani River, the following section occurs:

1. Basaltic rock.
2. Volcanic grit; amygdaloidal.
3. Brecciated conglomerate; the fragments being amygdaloidal, and the cement a ferruginous clay, with thin clay seams.



4. Same as 3, with a clay seam intervening.
5. Volcanic grit; very amygdaloidal; in irregularly bedded layers.
6. Volcanic grit; more compact; fewer amygdules; and regularly bedded.

About seventy-five yards above this place is a fine exposure of corrugated or wrinkled strata. The wrinkled beds are about two feet thick, the upper part showing the corrugations most, although they pervade the whole rock. The position this rock seems to occupy here, is between the layers of volcanic grit at the bottom of the preceding section, and a still lower bed of the same rock. These rocks are all traversed by veins of ferruginous clay, from half an inch to eight inches wide, and carrying calcite, zeolites, and occasional traces of copper ore.

A little further up the Lake the section exhibits the following members:

1. Basaltic bed.
2. Volcanic grit; no amygdules.
3. Volcanic grit; amygdaloidal.
4. Shaly amygdaloid.
5. Volcanic grit.
6. Volcanic grit.

These rocks dip southeast into the Lake, and each bed seems to have been deposited on a very irregular surface.

Beyond this point, and in the direction of Two Island River, the following Section occurs, in ascending order:*

* See Section from Inaonani River towards Two Island River, Pl. 1 N, Sect. 4.

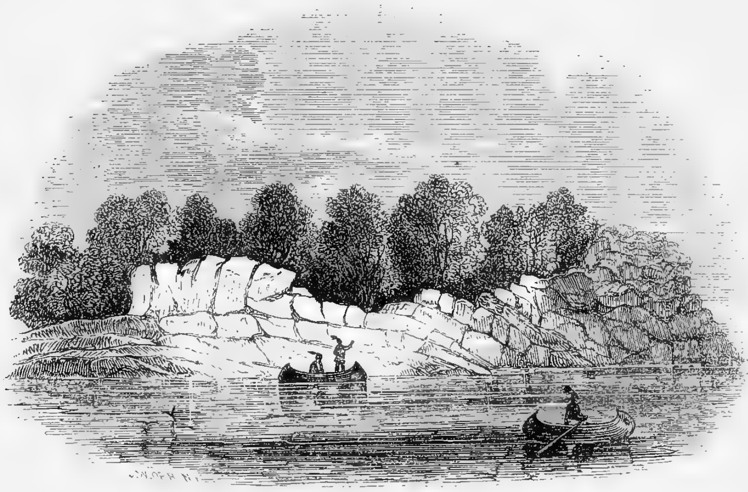
	Feet.	Inches.
1. Ferruginous shale, the upper part brecciated, ...	5	
2. Globular basaltic rock, the globular masses separated by seams of ferruginous argillite, ...	4	
3, 4, 5, 6. Beds of volcanic grit, ...	7	
7. Basaltic, sedimentary bed, ...	10	
8. Volcanic grit, ...	2	
9, 10, 11, 12. Brecciated volcanic grit, amygdaloidal; the partings between the layers containing seams of zeolites and calcite, with some thalite; the upper layers but slightly brecciated, ...	2	4
13. Shaly breccia, ...	2	10
14. Compact volcanic grit, slightly amygdaloidal, ...	3	
15. Volcanic grit, amygdaloidal, slightly brecciated in the lower part of the bed, ...	2	6
16. Volcanic grit, very full of amygdules; soft, and falling into fragments when struck. This stratum separates into layers five or six inches thick at some places; all the layers, however, possessing the same characteristics, ...	1	8
17. Wrinkled layer; filled with vertical cracks in every direction. These cracks are so numerous as to render it almost impossible to procure specimens. This rock, wherever exposed, seems to have been considerably water-worn before the deposition of the succeeding bed, .		3
18. A compact volcanic grit, purplish-coloured, especially where exposed, and divided by vertical joints. At the contact with the underlying bed, it is somewhat brecciated, ...	4	7
19. Wrinkled stratum. The corrugations extend through the whole bed. It is full of amygdules, containing zeolites. It is separable into thin layers, the top of each layer being corrugated, . . .	2	
20. Volcanic grit, grayish-coloured; tolerably compact; few amygdules, .	1	4
20½. Breccia, ...	2	
21. Volcanic grit (No. 183)—amygdaloidal, harder and tougher than the lower beds, ...	6	
22. Globular basaltic bed, ...	8	

Near the mouth of Two Island River, No. 183 comes to the lake-shore again, where it rests upon four feet of breccia, and is overlaid by a sheet of basaltic rock. The corrugated bed comes up to within two hundred yards of the mouth of Two Island River. The dip of these beds is to the southeast at an angle of from 9° to 10°. I consider this section interesting, principally showing in detail some of the various beds which make up the heavy deposits of metamorphosed and trap rocks found in the rivers of this neighbourhood. Some of them are, probably, composed entirely of materials evolved at the periods of trap eruptions, while others appear to have been derived in great part from sandstone beds, broken up by the intrusive rocks, and redeposited and cemented under the influence of trappean action. I have called them all by the same name in this section, though it is highly probable that some of the beds do not differ materially from some of the unequivocally metamorphosed sandstones.

The rock which forms the "Two Islands," is like No. 629, and bears north 30° east. On the easterly island it assumes a columnar form.

15. *Inaonani River.*—At the mouth of this river there is an exposure of ten feet

of volcanic grit (No. 162), extending along the bank for fifty yards. It is in near contact with a dike, and appears to be composed in part of basaltic material. The blocks which fall from the escarpment weather into rounded masses, very like those found in the beds of globular basalt. The following sketch, by Major R. Owen, exhibits the exposure at this place.



VOLCANIC GRIT AND BASALT, INAONANI RIVER.

In ascending the river* immediately after leaving the mouth, Nos. 163 and 164 come up, dipping to the southeast, at an angle of 29°, and forming mural precipices between forty and fifty feet in height. A quarter of a mile above, No. 165 is the top rock, and four hundred yards further there are several beautiful cascades, making a fall of one hundred and six feet in the distance of one hundred and twenty yards.

Some of the cascades have a nearly perpendicular fall of twenty feet, while at others, the water flows down inclined planes. The grit-beds alternate with shales at the head of the cascades, and dip southeast 13°.

About a quarter of a mile above the cascades the rock becomes harder, more compact, less amygdaloidal, and contains nests of prehnite (No. 166). The dip is here east-northeast 13°. Two hundred yards further on is a plateau, rising from ten to twelve feet above the river, made by No. 167. Through this rock a dike of No. 168 has been erupted. As the dike is approached, No. 167 assumes the character of No. 169. Half a mile further on, the dip changes to southeast, and four hundred yards further, the rocks are overlaid by clay and marl beds, about sixty feet thick. The rocks are concealed for the distance of three hundred yards, when they are exposed in the east bank of the river in ledges from eight to ten feet high. Nearly a quarter of a mile above this point, there is a ridge composed of No. 170, crossing the river, and containing large masses of No. 171. This is the same rock seen at the mouth of Kawimbash River, and at many other localities in this region. The ridge is about five hundred yards wide, and the river cuts directly through it,

* See Section from the mouth of Inaonani River northwesterly. Pl. 1 N, Sect. 6.

forming a gorge from eighty to one hundred and twenty feet in depth, and from fifteen to twenty feet wide. The rock, being soft, and easily acted on by water and atmospheric agents, has been worn down to an inclined plane, and no bold cascades occur in it, as in most other gorges met with. On the northwest side of this ridge, No. 172 comes in. It is in regular beds, from six inches to a foot thick. They appear to lie horizontally, or, if they dip at all, it is towards the ridge. A quarter of a mile further on, the rock met with is softer, amygdaloidal, and more like that at the gorge. Just beyond this is an exposure of thirty feet of volcanic grit, over the upper part of which is a fall of fifteen feet. The stream is divided by a rock at the top of the fall into two chutes, which meet at right angles about half way down the descent, and produce a unique and beautiful display.

Immediately above the falls, a high ridge of clay and marl occurs, which rests partly on the grit-beds and partly on metamorphosed shales, which emerge from beneath the grits. The clays and marls then conceal the rocks for the distance of a mile, where a very hard, flinty, porphyritic rock (No. 173) comes up, making rapids; the water descending through a narrow gorge, about twenty-five feet in fifty yards. This rock has a schistose structure when seen in the mass, and resembles very much the altered slates of the Wisacodé River, and those seen in the neighbourhood of Grande Marais, and on Spar Island. The rock here, however, is much more compact and flinty; in other words, is more highly metamorphosed. It bears great resemblance to the Palisade rock.

The next rock met with resembles the volcanic grits of the lower part of the river, but appears to have been much acted on by a dike of No. 174, which crosses the river, bearing north 45° east. The beds near the dike are very porphyritic, the embedded crystals being felspar. For the next two miles no rock is exposed, where No. 175 shows itself at the base of a hill, intercalated among beds of altered sandstone, resembling, in all respects, the altered sandstones of Black River. It continues for the distance of five hundred yards farther up stream, where it assumes more of a slaty character, is laminated, very hard, brittle, and, when struck, rings like phonolite (No. 176). A short distance further on, there is an exposure of twelve feet of argillaceous slate, slightly altered, but still maintaining its original characteristics in everything but colour. It is thinly laminated, with vertical joints, and cleavage planes dipping northeast 46°. This rock is exposed at various points off from the river, in the low hills which bound the valley. Its dip could not be ascertained. Continuing to ascend the stream, the slate is found to be interstratified with amygdaloidal shales (Nos. 177, 178), and two hundred yards beyond this a ridge of No. 179 crosses the river, bearing northeast and southwest. Beyond this the metamorphosed shale (No. 180) is intercalated with a bed of No. 181, which resembles some of the greenstones found near the Lake, and also with a bed of No. 182. For the distance of more than a mile beyond this no rock is visible, but numerous fragments of No. 176 occur, and at one point I noticed fragments of unaltered red sandstone.

The next rock seen is an exposure of about twenty feet of greenstone, which soon rises into a low ridge, and crosses the river, bearing northeast and southwest. It makes a rapid, with a fall of eight feet in thirty. It is jointed, the joints being

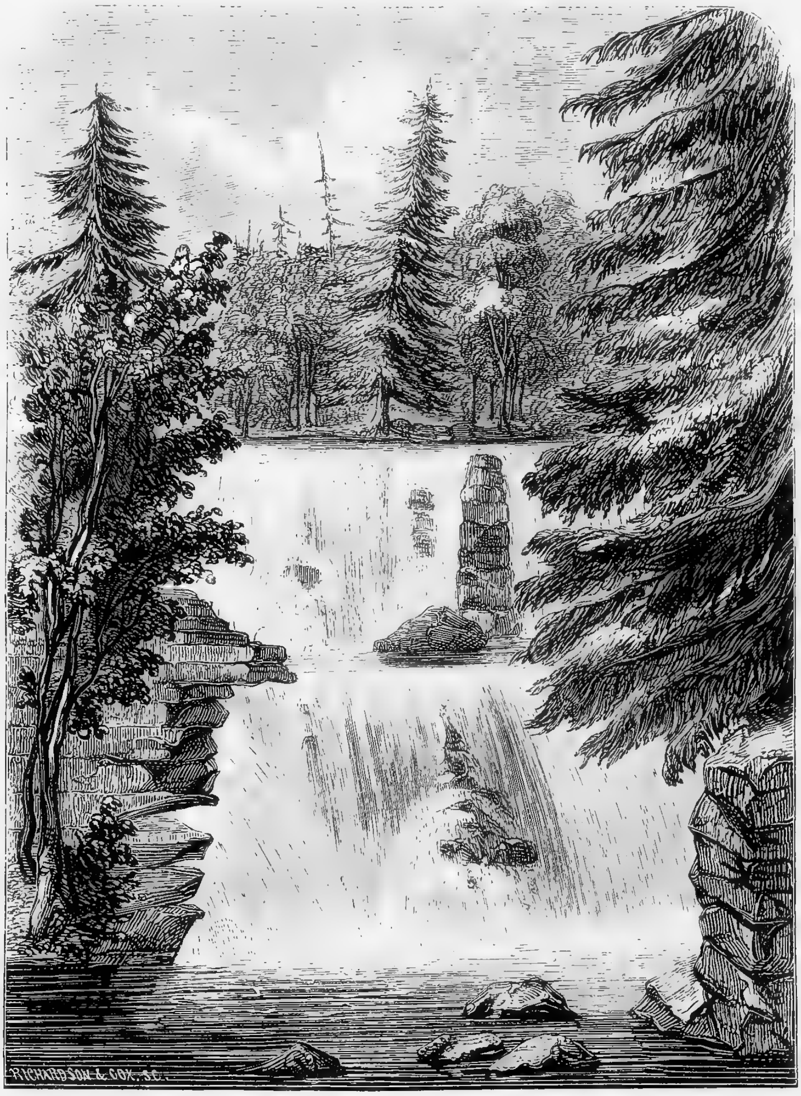
filled with thin seams of jasper. Beyond this place, hornblendic rock is seen at occasional points on the river, until the country becomes flat and swampy, and the river wide and sluggish. The distance from the Lake to the point where the exploration of this stream ceased, was estimated at twenty miles.

The dike which passes the mouth of Inaonani River, is a continuation of that forming the "Two Islands," and bears north 30° east. The rocks in contact with it are remarkably full of zeolites and thalite. The rocks described in the section of that stream, extend as far as the mouth of Kawimbash River, the grit-beds being overlaid by a bed of No. 630. The underlying rocks are very amygdaloidal, while the trap-bed is but slightly so. It appears as if the main body of the dike, which is easily broken down, had been carried away by the Lake, and left only the matter which had overflowed on the northwest side remaining, supported by the more compact metamorphosed beds. At a number of points, the wrinkled beds (No. 161) were seen on the lake-shore. The position they occupy here is between the compact beds and the shaly layers, and beneath a thin breccia. These wrinkles bear some resemblance to ripple-marks, and were, at first, mistaken for them. They are raised from a half to three-quarters of an inch, and are about an inch in width. In the mass, they look much more like piles of cordage than layers of ripple-marked rocks. They are, in all probability, the result of an overflow of molten rock in a somewhat viscid state. If so, I am inclined to the opinion, that the material was derived mostly, if not entirely, from pre-existing grit-beds, as it differs entirely in character from the basaltic beds so frequently met with. The underlying beds, as well as those above it, although considered to be of volcanic origin, are still sedimentary, and do not differ in composition from the wrinkled beds. That they were sedimentary deposits, and not the result of lava currents, is conclusively shown by the intercalation of thin seams of clay between them. Some of the beds are very thin, and even lamellated; some of them are very ferruginous, and others assume a crystalline aspect. Many small veins of calcite and ferruginous clay fill the joints and cracks, and some of them contain traces of blue carbonate of copper. That the grit-beds along this part of the coast were deposited in troubled waters, and subject to the action of variable currents, is shown by the great irregularity of the horizontal lines of bedding; and that they were afterwards affected by convulsive movements sufficient to throw the beds into a vertical position, is shown by the section a short distance below the mouth of Inaonani River, and at many other places.

16. *Kawimbash River.*—The explorations on this stream were extended only to the distance of four miles. At the mouth, the lower beds have been heaved up so as to form an arch; and a short distance further on is a fault, causing a displacement in all the beds of ten feet. The lower beds are in strata, from six inches to two feet thick, while the overlying bed is eighteen feet in thickness, massive, and jointed perpendicularly. At one point, where the bending of the lower beds has left a depression, it appears to have been filled up, previous to the deposition of the overlying rock, by from one to three feet of ferruginous shaly matter. Both the upper and lower rocks are amygdaloidal, and belong to the grits already described.

A short distance above the mouth a series of cascades fall through a narrow gorge. The rock here (No. 151) contains a great deal of thalite. About three hundred yards further up, a narrow ridge of No. 152 crosses the river, bearing north 45° east. It rises fifty feet above the general level.

Half a mile from the Lake, the upper rock (No. 153) mounts rapidly upward, and is cut through by a gorge with perpendicular walls seventy-five feet in height. The gorge is one hundred and fifty yards long, and generally from three to eight feet wide, but at no place over ten feet in width. The rocks dip to the southeast, at an angle of from 7° to 8°. As you ascend the stream, the gorge widens; and the numerous cascades, some of them with from ten to fifteen feet fall, soon bring the river-bed nearly to the level of the shores.

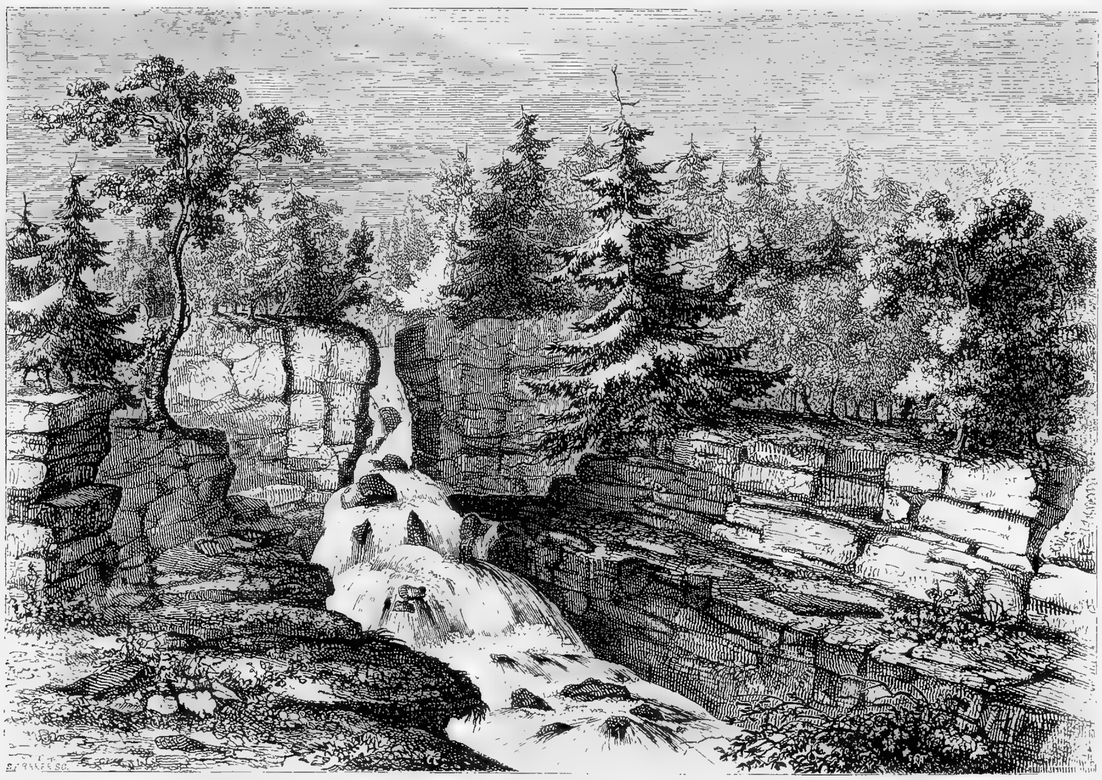


FALLS OF KAWIMBASH.

Near the upper part of the gorge, the top rock (No. 154) rests on wrinkled beds, such as have been already described as occurring on the lake-shore. They are five or six feet thick here, and are underlaid by beds of amygdaloidal grit.

The gorge disappears at the Great Fall, which is forty-five feet in width, and eighteen feet high. In very high water this fall is probably sixty feet wide, and over twenty-five feet in perpendicular height. Above this place the banks are low, and the river from fifty to sixty feet wide, and so continues for half a mile, when No. 154 again comes up, dipping to the southeast, at an angle of 11°, and forming the walls of a gorge fifteen feet deep, and from twelve to fifteen feet in width. This continues for the distance of four hundred yards, when the lower beds become very hard and compact, and assume a decidedly trappous character. The rocks here form several beautiful cascades, and are traversed by veins of No. 156, one of which is six inches wide. Two hundred and fifty yards further on, the rock becomes still more compact, and presents a somewhat crystalline aspect (No. 157); and immediately beyond this, a ridge of greenstone (No. 158) crosses the river. The lower part of this ridge resembles syenite (No. 159) in general appearance, while the central portion is more compact, and finer-grained, and more like the ordinary greenstones (No. 160). Beyond this, the river runs parallel with the ridge for half a mile, when it winds through low bottoms as far as we ascended it.

One mile beyond the last ridge mentioned, on the east side of the river, is a hill composed of red clay and marl, and overlaid by boulder-drift.



GORGE AND POTHOLES OF KAWIMBASH RIVER.

There are many remarkably large potholes in the rocks of this river. Indeed, the river appears to have cut out the gorges by the sinking of lines of potholes, which were gradually enlarged until they broke into each other. The sides of the

gorges still show large sections of holes, some of them, as along the margin of the upper gorge, high above the present water-level; while below them are the remains of potholes, some wholly, and others partially, broken into by the channel. In addition to the enlargement of the potholes by grinding, the freezing of water in them in winter has contributed, no doubt, towards breaking them into the gorge. The preceding sketch will illustrate the manner in which they occur.

The highest point near the lake-shore, between Fond du Lac Supérieure and Pigeon River, is a hill which bears due north from a point on the shore half a mile below the mouth of Kawimbash River. The distance from that point to the summit of the hill is about four miles. It was proposed by Colonel Whittlesey, who ascended it in company with Mr. R. B. Carlton, in 1848, to call it Carlton's Peak. It was measured, barometrically, by Major Richard Owen, in 1849, and the summit found to be nine hundred and thirty-seven feet above the level of the Lake. It is a prominent and important landmark to the voyageur, and commands a view of Point Keweenaw, the Porcupine Mountains, and a long extent of the south coast of the Lake. It also overlooks a large section of the country to the north. At the distance of twelve or fifteen miles to the northwest are several ridges, which appear to rise to about the same height as the Peak, and one of them, perhaps, is higher. The summits of the highest intervening ridges, some of which were measured, are only a little over seven hundred feet above the lake-level.

The summit of Carlton's Peak is composed entirely of felspar rock, which appears to have been erupted in the form of a dike, bearing east and west (No. 148). On the side next the Lake, and one hundred and seventy feet below the summit, No. 149 appears, bearing northeast and southwest; and one hundred and ninety-six feet below this, where the gentle descent to the Lake begins, No. 150 comes up, and forms a ridge about sixty feet above the general slope. Continuing to descend, a quarter of a mile further, is a ridge of greenstone, eighty feet high; and between this and the Lake are two low ridges of No. 150, which appear to be the same as the overlying rock found at numerous points on the lake-shore. Between all these ridges cedar swamps occur, and the rocks are entirely concealed, except at the summits of the ridges. The rocks underlying No. 150, however, are believed to be the same as those found on Kawimbash and Inaonani Rivers, and at the lake-shore. An analysis of the rock forming this peak (No. 148), yielded the results given below.*

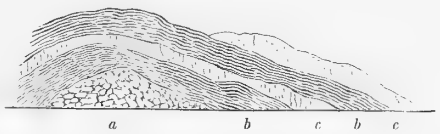
* BB.—Fuses with difficulty on the edges; with soda on charcoal, forms a white enamel; with borax, a colourless glass; with solution of cobalt, the fused edges become blue. Held in the forceps, a thin splinter fuses to a globule at the point, with effervescence, the globule being, when cool, white and blebby. Sp. Gr. 2·710.—Streak grayish white.

Matters insoluble in Cl H. ·522.	
Silica,	·462
Alumina, with a trace of iron,	·346
Magnesia,	·015
Lime,	·115
Potash,	·017
Soda,	·010
	·965

On the lake-shore, below the mouth of Kawimbash River, an earthy, decomposing amygdaloid is found, overlaid by a bed of basaltic rock, such as was found on the southern flank of Carlton's Peak. The cells of the amygdaloid are numerous, and filled with zeolites and thalite. The basaltic bed appears to have been deposited over an exceedingly irregular surface, previously worn on the now underlying amygdaloid, as shown by Section 2, Pl. 3, N.

The dip in this neighbourhood is very irregular. Further down the Lake, in the distance of half a mile, there are five alternations of trap and shale-beds to be seen. In one of these beds, a great many large wrinkles occur, the corrugations extending through the whole body of the rock, and looking more like layers of cables than anything else. The escarpment here is thirty feet in height, but as the Lake is descended, decreases to twenty and finally to ten feet, with a dip to the southeast of 9°. The bottom rock here is a brick-red shale, weathering into small caverns and arches, and overlaid by brecciated, amygdaloid, and metamorphosed beds of gritstone, from an inch to three feet in thickness. For the next three-fourths of a mile, the metamorphosed shales, with intercalated beds of trap, form the shore. The dip is about 11° to the southeast, except where a low upheaval of greenstone reverses it for a short distance, as shown in the following section.

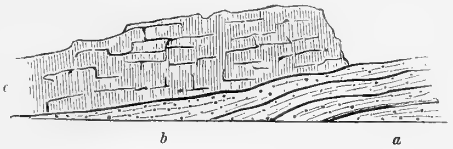
a. Greenstone.
b, b. Metamorphosed shales.
c, c. Trap-beds.



The dip of the bedded rocks is persistent for a long distance, because the ridge to which it is due, runs parallel to the lake-shore for many miles, and at about the same relative distance from it. The dip, however, is often exaggerated at the shore, in consequence of the washing away of the lower soft beds, and the consequent subsidence of the upper strata in the direction of the Lake.

A mural precipice in this vicinity exhibits, in descending order,

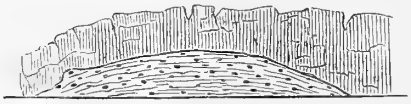
1. A bed of coarse-grained trap, consisting of felspar and hornblende, with some tolerably large fragments of other rocks embedded in it.
2. Amygdaloidal shales, decomposing with facility, and causing the upper rock to form overhanging precipices.
3. Amygdaloid, shelving into the Lake, and containing numerous veins of calcite, laumonite, and quartz.



c. Trap-bed.
b. Shaly amygdaloid.
a. Amygdaloid.

The dip is apparently affected by the nature of the surface on which the trap-bed has been deposited, which appears at many points to have been undulating. This gives to the strata the appearance of having been subject to slight elevatory movements, as shown in the section on p. 182. At some places, the shaly amygdaloid

is variegated by yellowish-red spots and stripes, precisely like those found in the shaly sandstones of some parts of the south shore. A short distance above the



a. Trap-bed.
b. Shaly amygdaloid.

mouth of Kamanosisatikag River, are some small rock-islands, near the lake-shore, two of which are connected by a natural arch, as seen in the following sketch by Major R. Owen. The space between the abutments has been cut out of the soft,

NATURAL ARCH, LAKE SUPERIOR.

shaly amygdaloid by the action of the waves, while the bridge which spans it is made by the more unyielding overlying trap-bed. At some points in this vicinity the bedded trap is from twelve to twenty feet thick, and overlaid by a deposit of drift.

17. *Kamanosisatikag River.*—At the mouth of this river, the lowest rock is an earthy, red amygdaloid, from eight to ten feet thick, in beds, with very thin laminæ of clayey matter between them, and over the amygdaloid is about twelve feet of volcanic grit, with thin bands of No. 133 intercalated between the beds.

About half a mile from the Lake, the river runs through a narrow gorge, not over two feet in width at some points, with perpendicular walls from twenty to thirty feet high. This gorge is represented on the opposite page, from a point a short distance below, as sketched by Major R. Owen. The section up to this place shows, in descending order, 1st, the rock seen at the mouth; 2d, shaly amygdaloid; 3d, metamorphosed, siliceous shale; all dipping to the southeast at an angle of 9°. Ascending the river a short distance further, a purplish-coloured, metamorphosed slate comes up (No. 139), over which there is a fall of twenty-five feet, in four or five cascades. This rock contains occasional crystals of flesh-coloured felspar disseminated through it. About three-quarters of a mile above this, is a ridge, of which No. 137 forms the summit. It rises to the height of five hundred and eleven feet above the lake-level, according to the measurement of Major Owen, and is the first ridge met with in

ascending the river. On the northwest side of this ridge, beds of volcanic grit and breccia (Nos. 140, 141), are found dipping to the northwest. The beds are thick,

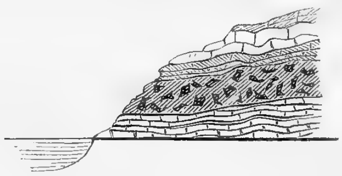
GORGE AND FALLS OF KAMANOSISATIKAG.

with perpendicular joints. The upper layers, as exposed in a mural precipice at the river, are very amygdaloidal. Some of the cells are lined with a thin coating of green carbonate of copper. (No. 142.)

About two hundred yards higher up stream No. 139, again comes up, with an intercalated bed of No. 137, and dips to the southeast as before. Where it emerges from beneath the amygdaloid, several cascades are formed, the entire fall being in all about twenty feet. As this rock extends up the river, the lower part becomes thinly laminated, and assumes a grayish colour, while the upper beds still continue purplish. (No. 138).

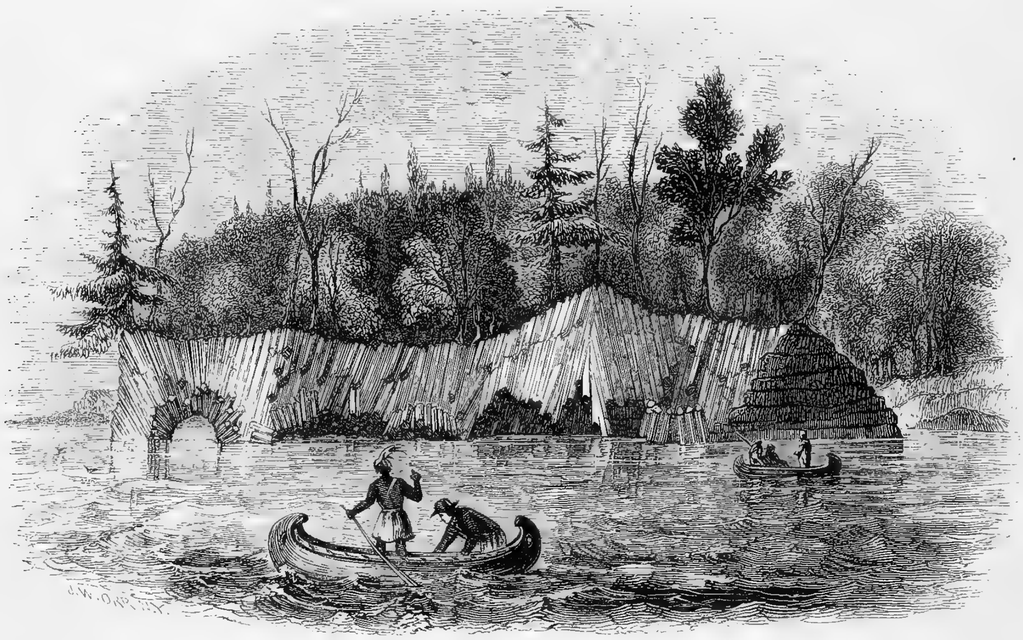
Beyond this point, for the distance of three miles, the rocks are concealed by high hills of red clay and marl, which slope down to the margin of the river. On the east side of the river, we ascended a ridge of greenstone (No. 143), the summit of which is over seven hundred feet above the lake-level. This ridge, which is about six miles from the Lake, is so heavily timbered, that the view is rather contracted; but from a point about two-thirds the distance up, a good view was obtained of two chains of hills to the west, both of which have high perpendicular escarpments on the northwest side. From the foot of this ridge, the slope is about three miles to the nearest point on the Lake, and in that distance is an exposure of No. 144, and a dike of greenstone.

A section of the rocks immediately below the mouth of this river, is exhibited in the annexed cut. The underlying rock is a shaly amygdaloid; above that, a bed



e. Shaly amygdaloid.
d. Volcanic grit.
c. Volcanic grit, with shales.
b. Breccia.
a. Shaly amygdaloid.

of amygdaloidal breccia, and over that, a bed of volcanic grit (No. 146). These beds are all somewhat disturbed, and traversed by veins of calcite, in one of which I found traces of green carbonate of copper. In proceeding from the Lake, the metamorphosed shales become much thickened, and are associated with beds of altered grit, and occasional exposures of a corrugated bed. They form the shore of the first two bays, overlaid by a bed of trap. In the third one, there are alterations of shale and thin beds of trap (No. 133), which are greatly disturbed, and dip south and southwest. At the point of this bay, is a beautiful exhibition of basaltic columns projecting into the Lake, of which the following sketch by Major Owen will give a much better idea than a written description. The exposure is about



BASALTIC COLUMNS, LAKE SUPERIOR.

twenty feet in height, and the columns rest on beds of metamorphosed grit, overlying decomposing amygdaloidal shales; showing conclusively, I think, that the basalt here is an overflow, and does not occupy the original site of eruption.

Beyond this point the exposures are low, and consist of metamorphosed shale and sand-rock, until the middle of the bay is reached, where they are cut through by a

basaltic dike, bearing east and west. From this place to the mouth of Cut Face River, low exposures of metamorphosed sandstone, with alternations of trap and shale beds, and, at one point, a bed of breccia beneath the shales, form the shore. These rocks appear to be capped almost everywhere by a bed of No. 133.

18. *Cut Face River.*—This stream is forty feet wide at the mouth. Seventy-five or eighty yards up, rapids occur; and above that point the river runs through a narrow gorge with perpendicular walls, varying from twenty to fifty feet in height, and from six to twenty feet in width. For the distance of three-quarters of a mile above the first rapids, the water falls in a series of cascades, from five to fifteen feet high, and seldom more than twenty or thirty yards apart, often much nearer together. A trap ridge then crosses the river, bearing east and west. Above this the rocks are exposed for more than three miles, the river still flowing through a gorge. In this distance two other trap ridges cross the stream, bearing east and west. Just below the highest point to which we ascended, a greenstone ridge (No. 119) crosses the river, bearing east-northeast and west-southwest. The bed of the river where this ridge crosses is three hundred and seventy-six feet above the lake-level.

The lowest bedded rock at this place is No. 120.* In near contact with the greenstone, it bears some little resemblance to syenite. Above No. 120 is a bed, ten feet thick, of metamorphosed shale; and overlying that, about thirty feet of altered shaly sandstone, with beds of volcanic tufa (No. 121), which reaches to near the top of the ridge, and is overlaid by a breccia composed of angular fragments and rounded pebbles, which appear to be derived entirely from the shaly sandstone. Over the breccia is a thin bed of greenstone, and above that clay and marl beds. Between the third and fourth ridges is a small stream, in the bed of which the metamorphosed shaly sand-rock, with intercalated beds of tufa (Nos. 122, 123), rests on volcanic grit-beds (Nos. 124, 125). These are the same rocks seen higher up stream, near the greenstone ridge, and the lower beds here as well as there have a syenitic aspect. The next rock (No. 127) is a bedded trap, and near its junction with the siliceous shale (No. 126) which overlies it, presents a laminar appearance. Above (No. 126) is a breccia, formed of sand-rock and shales; and over the breccia (after passing the greenstone dike), comes an amygdaloid, like that described as overlying the shales at other places.

A short distance further down the river is a quartzite, which, at some points, resembles syenite very much. It is, however, made up principally of rounded grains of quartz, with some of felspar and hornblende. I consider it an altered sandstone, the materials of which were derived mostly from the older granitic and hornblende rocks. Some of the beds have a porphyritic appearance, in consequence of the presence of small fragments of quartz (No. 128). This rock is overlaid by breccia, and the breccia by shaly red sandstone, like that which occurs on Oginekan River. Over the red sandstone, and over most of the rocks already named, are beds of red clay and marl, from thirty to forty feet thick.

* See Sect. 6, Pl. 3, N.

Continuing to descend the river, metamorphosed slate, alternating with trap-beds (Nos. 129, 130), again comes up, overlaid by red sand-rock breccia. No. 131 is from one of the layers of trap, and No. 132 from the greenstone ridge. This last rock is the same as No. 115 found on the lake-shore below the mouth of this river, associated there, as here, with amygdaloidal sand-rock.

Below the mouth of Cut Face River, on the lake-shore, the metamorphosed rocks, with intercalated beds of trap, make the shore, nearly to the mouth of Oginekan River. At one point there is a small pocket, with mural walls from thirty-five to forty feet in height. Here the sedimentary rock (No. 118) has been completely fused, and resembles in colour and structure the slag from a furnace (No. 117). For some distance the metamorphosed rocks have been greatly disturbed, and present the appearance of having been melted. Sometimes the beds stand vertically, and at others recline at all angles to the horizon. The overlying trap-bed varies from eight to twelve feet in thickness. For the last two miles the lake-shore is entirely composed of siliceous shales (No. 103), overlaid by volcanic grit (No. 114), except at one point, where these rocks are traversed by a trap-dike, six feet wide, and bearing north 45° west. The underlying amygdaloidal shaly beds, throughout the whole distance, weather into caverns, arches, and pillars.

19. *Oginekan River.**—Opposite the mouth of this river, are some small rock-islands, the upper beds of which all appear to be metamorphosed rocks (No. 94), such as are found on the main shore. They form a chain, bearing northeast and southwest, and if prolonged southwesterly, would strike the point making the upper side of Oginekan Bay. The projecting points of the main shore are formed by a low ridge of basaltic rock overlying metamorphosed slate. Both rocks assume the

COLUMNAR BASALT AND ALTERED SHALE, LAKE SUPERIOR.

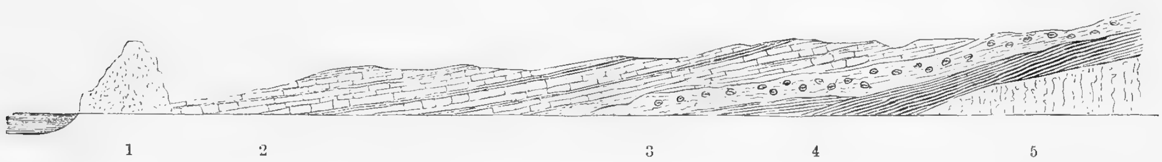
columnar form, the columns being nearly perpendicular. Inside of the ridge, in the bottom of the bay, is an exposure of altered shales and sandstones, overlaid by a bed of trap, as seen in the preceding section.

* See Sect. 3, Plate 1, N.

The rock which forms the points of the bay at this place is greenstone (No. 102). Then succeeds, in passing up the stream, a volcanic gritstone, No. 95, highly metamorphosed, and overlaid by a bed of trap. These beds dip northwest at an angle of 19°. Above this, on the east side of the creek, is an exposure of No. 98, ten feet in thickness where it first shows itself, but continues to increase in thickness and dip as the creek is ascended, until it dips 39° northwest. The next rock is a trap-bed, conforming to the dip of the rocks with which it is associated, and a short distance beyond that, a dike of columnar trap, bearing nearly east and west, traverses all the beds.

On the top of the first ridge, which is about one hundred and fifty feet above the level of the lake, the surface for the space of several acres, is almost entirely bare, and presents numerous scratches and grooves. They are of all sizes, from a mere scratch to two inches in depth, and from one to four inches in width at the top. Their general direction is east-southeast, and southeast. The ridge slopes gradually towards the Lake in a southeast direction, the bearing being northeast and southwest. The northwest side of the ridge is abrupt, and presents a mural escarpment from twenty to thirty feet in height, with a wide talus below. The highest point of this ridge is about three hundred feet above the Lake. Beyond this ridge, the shales continue for about a quarter of a mile, dipping to the northwest, when they are concealed by clay and marl beds, and when they again appear, the dip is to the southeast, at an angle of 6°. They are porphyritic at this place. The clays and marls, which are from twenty-five to sixty feet thick, soon cover them again. In the upper part of these beds are many pebbles and small boulders, and on the top, many large boulders of granite.

Another exposure, on the opposite side of this bay, gives the following section.



1. Greenstone ridge, at the lake-shore.
2. Red sand-rock and shales, the joints and seams full of laumonite.
3. Breccia, composed of angular and rounded fragments of sand-rock and shales.
4. Metamorphosed argillaceous slate—rings like clink-stone when struck with a hammer. It is very thinly laminated.
5. Greenstone.

On a small creek near this place is a great exposure of sandy shales and sandstone, like those on the lake-shore. The shales are in layers, from one to six inches thick. Some of them are hard, while others are soft and disintegrate easily. They all dip to the southeast, at an angle of 7°. A quarter of a mile up the creek, in the vicinity of a trap-dike, the joints and seams of these beds are filled with laumonite.

These beds come up, as the creek is ascended in the following order:

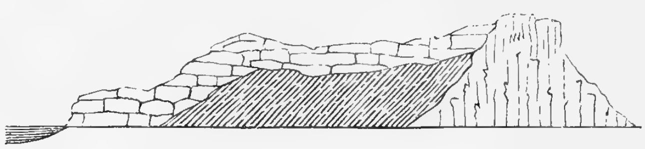
1. Thin shales (No. 103), with seams of clay and nests of laumonite.
2. Thicker layers of shale, more indurated, with occasional cells filled with calcite and zeolites.
3. Beds of Nos. 104, 105, from two to four feet thick, hard, of a deep red colour, and showing dark greenish-coloured lines, when broken. Some of these beds are ripple-marked.
4. Beds of No. 106, still harder and more compact; pebbly near its junction with the other beds.

5. Same as Nos. 105 and 106, highly metamorphosed; amygdaloidal, the cells being filled with calcite, laumonite, and other minerals. (Nos. 107, 108, 109.) This rock loses its distinctly stratiform character. and the shales on which it rests (Nos. 110, 111, 112) pass into a highly metamorphosed rock like No. 100,

6th. Trap ridge, bearing east 15° north. This is, probably, the ridge which comes to the lake-shore above, where it exhibits a columnar structure, and has been set down as basaltic rock. Above this point, the walls between which the creek runs are composed of metamorphosed shales and sand-rock (Nos. 107, 108, 109), which continue for a long distance, with occasional exposures, in the bed of the stream, of Nos. 110, 111, 112. Above the last exposure of these rocks, the bed of the creek is literally filled with boulders of No. 115.

The beds resting against the greenstone are highly brecciated (No. 116), and consist, almost entirely, of fragments of Nos. 107 and 110. The exposures at this place indicate very clearly, I think, that the greenstone was erupted about the beginning of the deposition of the red sandstones and sandy shales, as the thick breccia which underlies them is composed entirely of the lower beds of the sand-rock and shales, and shows every evidence of having been the result of violent disturbance, while the overlying beds, which are soft and easily fractured, exhibit no signs of having been disturbed since their deposition, except, perhaps, in an increase of dip, which may have been occasioned by gradual upheaval or subsidence, long posterior to the period of eruption of the greenstone. The sand-rock beds in this neighbourhood are nearly all ripple-marked. The highest ridge measured here was four hundred and eighty-five feet above the lake-level.

In the large bay beyond, there is an exposure of metamorphosed sand-rock and slates, in which the sand-rock is found to rest unconformably on the slates, as shown in the subjoined figure. The slates dip to the northwest, at a high angle, and rest against a heavy dike of greenstone.



a. Greenstone. *b*. Slates. *c*. Metamorphosed sand-rock.

Between this place and Bitobigungk Bay, the lake-shore is made by low exposures of metamorphosed rocks, with an occasional exposure of trap at the small promontories.

The rock (No. 633), which makes Bitobigungk Point, as well as the bay above, bears east and west. It is very regularly jointed, and forms three, four, and five-sided columns. On the large exposure of this rock, which slopes into the Lake from the south side of the bay, are numerous grooves and scratches. There are, at least, two sets, one having an east-and-west direction, and the other bearing west 25° south.

While the body of the rock is very ferruginous, and of the colour of iron-rust, it is of a light-gray colour in the joints, which colour extends into the body of the rock for an inch or more from the joints. This discoloration has been attributed

to the action of gas permeating the rocks from below, but I am inclined to attribute it to the action of water. The same phenomenon occurs at many other places on the lake-shore, but it has not been observed at any point inland where similar rocks occur in situations removed from the constant action of water. About the centre of the chain, which encloses the bay on the lake-side, the rocks are polished and excavated, to the depth of four or five feet and the width of ten or twelve. This great gutter is literally covered with small parallel grooves and scratches, and extends the whole length of the exposure. The rock is an exceedingly indestructible one, and there is not a groove or scratch in the direction which masses of ice, moved by the present waters of the Lake, would be compelled to take.

The entrance to the bay is through a narrow gap in the rock just described, with barely water sufficient to permit a Mackinaw boat to pass. The bay, which is sheltered from every wind, is situated between two ridges, about six hundred yards apart, bearing east and west; and its peculiar shape is given it by a north-30°-east dike, which shows itself at the extreme eastern end of the first ridge, and forms the barrier between Bitobigungk and the great bay below, and two other dikes with the same bearing, which are seen low down in the next bay. The trough between the east and west ridges, as seen at other points, contains a thick deposit of soft shales, and in them the basin of the bay has been excavated.

In describing the rocks on the lake-shore between Bitobigungk Bay and Wisacodé River, I shall begin at the last-named place and proceed westerly.

In the bay immediately above the mouth of the Wisacodé, are several low exposures of metamorphosed clay-slates (No. 73), associated with a basaltic bed (No. 72). The joints of the altered slates present a remarkable appearance, having been filled, apparently, with melted matter of the same rock. No. 73 continues along the shore, past the small rock-islands, as far as the deep bay into which Diarrhœa River empties. It is in low exposures, at the points separating the bays, and occasionally projects from beneath the sands of the beach. At one locality, it is overlaid by a bed of trap. In the bottom of the bay there is a greenstone dike (No. 74), twenty-six feet wide, and bearing east 10° north. At the junction of the dike with the sedimentary rock, large cells are developed in the latter (No. 75), which contain laumonite and other zeolites. The joints of the trap are encrusted with heulandite. The first range of hills along this part of the coast, are from two and a half to three miles back from the shore, and bear northeast and southwest.

Near the west end of the bay the altered slate dips southeast 14°. At the point it is overlaid by a bed of trap. At the point opposite the large island, No. 638 is the overlying rock. It contains many portions of a very hard trap, numerous thin veins of quartz, and many egg-shaped cavities filled with the same mineral, the quartz being surrounded with a coating of chalcedony. A narrow dike, bearing north and south, traverses the bedded rocks at this place. Just above the point is an exposure of amygdaloid, with beds of altered sandstone (No. 76) above it, and over them a bed of trap. Some portions of the exposure are earthy-looking, while other parts present every appearance of having been fused. A short distance above this place, the beds consist of metamorphosed sandstone, shale, and seams of clay, as illustrated in the following section:

a, *a*. Volcanic grit. *b*. Volcanic grit, amygdaloidal. *c*. Volcanic grit, with shales. *d*. Metamorphosed sandy shales. *e*. Metamorphosed sandstones. *f*. Metamorphosed sand-rock.

The top rock (No. 76) is from eight to ten feet thick, and differs in colour, grain, hardness, and compactness at different places. In some parts it abounds with amygdules, and in others contains but few. It is separated from No. 77 by from six to eight inches of thinly-laminated siliceous material. No. 77 is about ten feet thick, and contains numerous amygdules and thin veins, containing calcite, zeolites, thalite, and chlorite. It is jointed, and traversed by cracks in all directions. The rock on the sides of the joints, from one to three inches in breadth, appears to be more highly metamorphosed than in other parts; caused, probably, by having been long under the influence of ascending vapours, after other parts of the rock had measurably cooled.

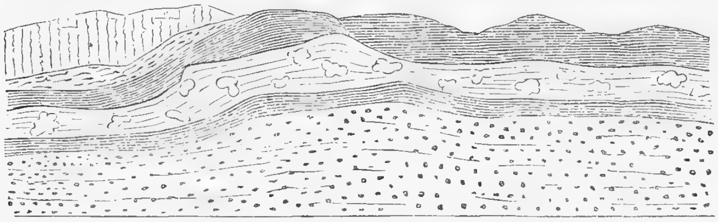
The next rock (No. 78) is very soft in some places, and disintegrates easily, while in others it is hard. In general, it is broken down with facility by the action of the waves, and washes into caverns. It contains large nests filled with laumonite and calcite. Where it is in near contact with trap rocks, it is traversed by veins of argillaceous iron ore. Some of the layers are separated for long distances by seams of laumonite. A portion of this rock, which is from five to twelve feet in thickness, rests on a brecciated conglomerate, which contains, however, pebbles only of its own kind. The breccia is only to be seen in the near vicinity of the trap. Nos. 79, 80, 81, 82, 83, were all taken from the same bed, at the same elevation, and within a distance of six feet. These beds dip southeast at an angle of 11°. Eighty-five yards further the dip is reversed, and the beds just described are overlaid by basalt (Nos. 84, 85), as shown in the section above. On the west side of the basaltic exposure, near the junction of the breccia with it, are many nests containing green earth.

The difference in the appearance of the same beds of rock, after having been subjected to metamorphic influences, is owing, no doubt, to accidental variations in the original constitution of the beds. The differences in the mineral contents of the beds may, I think, be accounted for in the same way, taking into consideration the particular metamorphosing agents, to the influence of which they have been subjected. It may be set down as always the case, that minerals of a different character from those found in the altered beds, are developed in the bedded traps, and at the junction of dikes belonging to different systems. And it is also true, that where the sedimentary rocks are overlaid by basaltic beds, the minerals are far more abundant in the sedimentary beds than in the trap. The section on the next page occurs a short distance above the one last given.

The top layer here resembles very much the altered porphyritic shales of Wisacodé River.

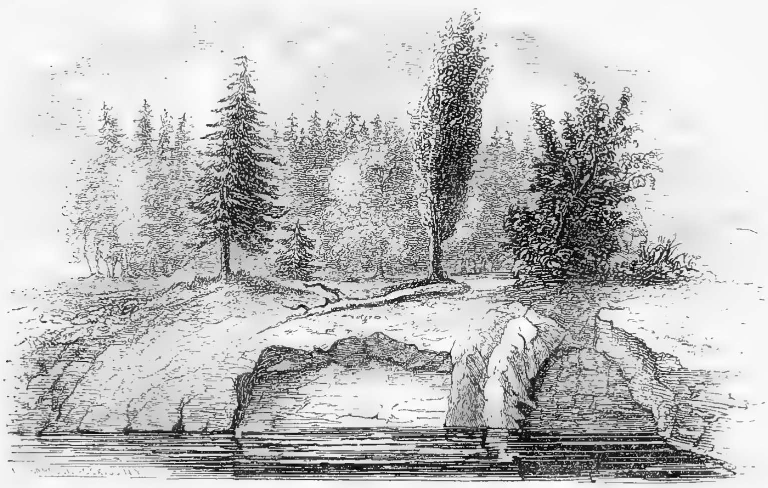
About half a mile above this place, is a low exposure of metamorphosed rock, overlaid by a bed of trap. The trap is in a broad sheet, from eighteen inches to two

feet thick. At one point there appears to have been a depression in the sedimentary rock at the time of the overflow, and in this depression a gutter has been formed,



a. Shaly amygdaloid. *b*, *b*. Shale, with clay seams. *c*, *c*. Shale, with nests of minerals. *d*. Quartzose porphyry.

filled with a breccia composed of small fragments of sand-rock cemented by the trap. The gutter extends into the Lake, and can be traced for some distance from the shore. The following sketch, by Major Owen, exhibits the section at this place.

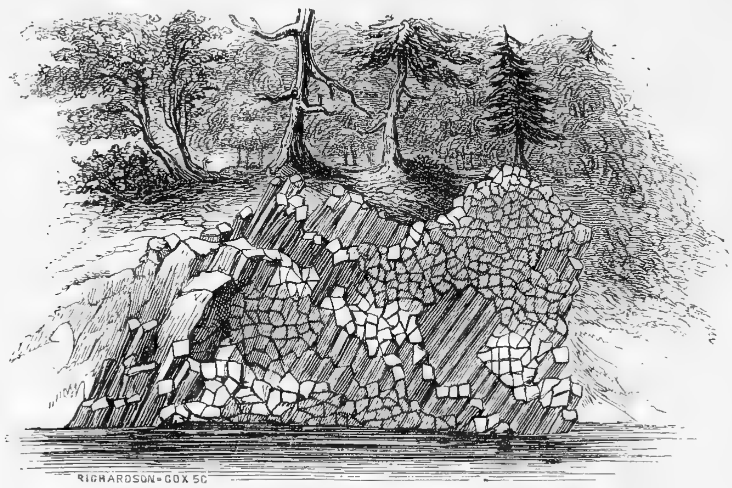


SHEET OF TRAP OVERFLOW, LAKE SUPERIOR.

The sides of the gutter are from six inches to three feet in height. The sandstone (No. 88) immediately under the breccia is very much altered, and looks like sandstone burnt in a furnace. That which underlies the trap-bed is less altered (No. 89), but assumes a somewhat trappous appearance at the contact. A portion of the bed near the gutter has the appearance of jasper. (No. 87.) The direction of the gutter is from north to south. The first high ridge is about a mile and a half north of the lake-shore.

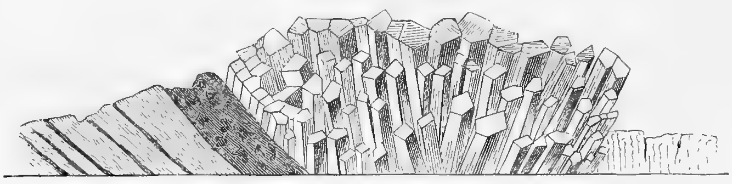
A short distance further on, is an exposure of siliceous shale (No. 90), overlaid by altered sandstone (No. 89); both rocks dipping southwest at an angle of 12°. Just above the long point below the mouth of Manitobimitagico River, and near the mouth of a small stream which comes in there, are some low exposures of No. 637. At the point itself, the trap overlies a breccia, from eight to ten feet in thickness, and filled with zeolites. These rocks continue to form the shore as far as the mouth of Manitobimitagico River, a short distance above which a trap ridge strikes the

lake. On the northwest side of the ridge, this rock (No. 92), presents beautiful clusters of columns, as shown in the subjoined sketch by Major Owen. They are



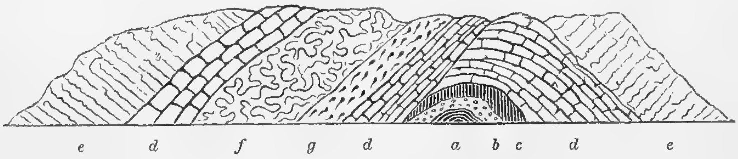
CLUSTERS OF INCLINED COLUMNAR BASALT, LAKE SUPERIOR.

mostly pentangular, and from ten to eighteen inches in diameter. The sedimentary rocks near the trap dip 30° to the northwest, and the columns make about the same angle with the horizon, favouring the idea that the basaltic rock is not a dike, but a bed. At another point, the columns stand without order or regularity in reference to the bedded rocks, and are separated from them by four feet of breccia, as shown in the annexed cut, and such as is found to underlie the basaltic beds of other



a. Basaltic rock. *b.* Breccia. *c.* Metamorphosed slates. *d.* Quartzose porphyry.

localities. The slate within ten feet of the trap is very much altered, and resembles the rock making the Great Palisades; farther off, it becomes less and less changed, softer and more amygdaloidal. The ridge which begins at this point crosses Manitobimitagico River, about a mile above its mouth.

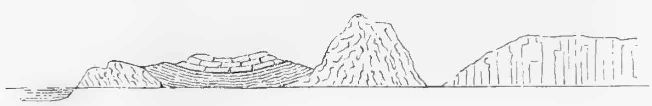


a. Shale. *b.* Amygdaloid. *c.* Shaly beds. *d, d, d.* Volcanic grits. *e.* Basaltic rock. *f.* Breccia. *g.* Bed of trap.

Half a mile farther up the Lake, the bedded rocks are very much disturbed, as shown in the preceding section, and their relations obscured by a fault.

It is believed, however, that the confusion in the beds at this place has been the result of more than one disturbance, perhaps of several. Beyond this, the trap ridge, which passes back of Bitobigungk Bay, is seen about half a mile north of the shore. Occasional exposures of a north-10°-east dike (No. 636), which begins in the second large bay below Bitobigungk, are seen rising above the water at the bottoms of the bays, and forming small pockets; and about the centre of the large bay just named, is a narrow, prismatic dike, bearing north 30° east. The sedimentary rocks in the neighbourhood of these dikes are very much altered. In the large bay between this and Bitobigungk, the rocks lying between the ridge already mentioned as forming Bitobigungk Point, and the one passing back of the bay, are shown in the following section. At one point these rocks are traversed by a trap

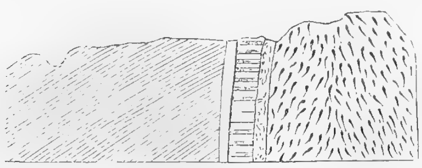
a, a. Greenstone.
b. Shales.



c. Metamorphosed shale.
d. Altered sandstone.

dike, bearing northeast and southwest, which is not shown in the section above. At the junction of the dike with the sedimentary rock (No. 93), it is very much altered, and for a foot or more is slightly brecciated. The dip of the rock, which is southeast 14°, is not such as to indicate that much violence was done it at the time the fissure was filled with the matter of the dike; and in this respect it resembles the slate walls of many of the narrow dikes in the neighbourhood of Pigeon River. The subjoined figure shows the junction on one side of the dike:

a. Metamorphosed shales.
b. Greenstone.
c. Dike.



d. Joint, filled with calcite and zeolites, and fragments of greenstone.
e. Joint, filled with decomposing chlorite.

Next the trap is a seam of fragments, separating it from a joint, six inches wide, filled with decomposed chlorite; and between that and the sedimentary rock, is a narrow seam, containing calcite and some zeolites.

The exposure here is mural, and from ten to fifteen feet in height. It is a shale (No. 635), in beds, from one to six inches thick, and near the trap dikes is changed into a hard, firm quartzite, in which numerous crystals are developed. The colour is also changed, for the distance of a few feet, to a purplish red. Between the two north-30°-east dikes, which occur in the bottom of the bay, one hundred and twenty yards apart, the rock has a baked appearance, and in many of the layers, crystals of felspar and quartz have been developed, so as to give it a porphyritic aspect. Near the northwest dike, druses have been formed in the altered rock, containing crystals. The colour is also changed to a deep red. At some places, however, it loses its red character entirely, and resembles a drab-coloured hornstone. Many of these beds are very similar in appearance to the Palisade rocks.

20. *Wisacodé River.*—This river is known to the French voyageurs by the name of "Bois Brulé." In order to distinguish it from a river of that name which empties into the Lake on the south shore, the Chippewa name is given here. It is about twenty yards wide at the mouth, and deep enough to allow a large Mackinaw boat to enter.*

About five hundred yards above the mouth, the river is crossed by a ridge of No. 59, making rapids, and a fall of ten feet. There are twenty-five feet of rock exposed. Back from the river, the ridge rises to the height of three hundred feet. Two hundred and fifty yards higher up stream is an exposure of No. 60. This rock weathers easily near the water, and forms a gorge from eight to twenty feet in width, with mural precipices from forty to fifty feet in height. It dips to the southeast, and contains thin veins of calcite, with an east-and-west direction. A quarter of a mile above the gorge is a ridge of greenstone, which crosses the river, bearing north 45° east; and beyond that No. 60 comes up again, bearing southeast, at an angle varying from 15° to 25°. Two hundred yards beyond the ridge, a small stream comes in on the west side; and in the rocky point at the junction are several potholes, from eighteen to twenty inches in diameter, and from three to four feet in depth. There is a rapid here, with a fall of nine feet.

Beyond this No. 60 continues to form the channel, until a fall, consisting of several cascades, one of which falls twelve feet perpendicular, is reached. The whole fall is thirty-eight feet. No. 60 is seventy-one feet thick at this place; and in the high hill, on the west side of the river, greenstone shows itself, and is believed to overlie the rock below. The nature of the exposure, however, prevented this from being satisfactorily ascertained. Immediately above the fall No. 60 forms a gorge, with mural walls, which continue a short distance to a fall of twenty feet in height. From the bottom of the fall first mentioned, to the top of the walls of the gorge, is one hundred and fourteen feet. The rock then mounts upwards, and forms a ridge nearly three hundred feet high, and is composed, as far as could be ascertained, of No. 60 up to the top.

Half a mile beyond this, clay and marl beds occur, two hundred feet thick, forming a narrow ridge, which slopes down to the margin of the river. No. 62 is the last rock exposed before reaching the clay-beds. Three other high ridges of clay and marl come to the river, and conceal the rocks, except at a few points, where the base of a ridge of hornblende rock (No. 63), estimated to be five hundred feet in height, is washed by the river. On the side next the stream is a mural escarpment, resembling in all respects those seen on Pigeon River and along the boundary line. On the opposite side of the stream, the ridges seen from the top of this one appeared to be about the same height, and are probably composed of the same rock. The bearing of all of them is northeast and southwest.

The river from this point is a continuous rapid. Just beyond the high ridge No. 63, is an exposure of slaty hornblende (No. 64), over which the river falls in a series of beautiful cascades, forty feet in seventy yards. There are about eighty feet of rock exposed. On the east side, the escarpment is mural, and exhibits a

* See Section from the mouth of Wisacodé River, northwesterly. Pl. 1, N., Sec. 5.

vein of jaspoid rock, having an east-and-west course. No. 64 continues for some distance, when clay and marl beds again occur, from a hundred to a hundred and fifty feet high. On the high ridges fragments of slightly altered red sandstone (No. 65), were found in the upper part of the marl. The next rock exposed is a high ridge of greenstone, bearing northeast and southwest. It is a very heavy exposure, and is cut through by the river. It forms a mural precipice on both sides of the stream.

The next rock is quartzose porphyry (No. 67), which seems to be a highly metamorphosed variety of No. 62. It bears great resemblance in some spots to the slates of Spar Island. It is exposed on both sides of the river. At one point it appears to be overlaid by a heavy bed of greenstone, but the fact could not be established with certainty. It dips at one of the exposures southwest at an angle of 18°. Next comes a high ridge of hornblende rock (No. 66), which seems at some places to graduate into syenite. Some low ridges succeed, and then a high one of No. 68, which is exposed on the slope of the hill for some distance. The bed of the river is much obstructed by fragments of it. This rock continues up to the first lake through which the Wisacodé passes. Here we found an old Indian camping-ground. The Grand Portage band come to this place, in the spring of the year, by way of Mud Lake, for the purpose of making sugar. The country beyond this is nearly impassable, except in canoes, on account of the numerous lakes and swamps, and we therefore ceased our explorations at this point. On our way back to the lake, we came to a small stream which flows for several miles through a deep narrow gorge in No. 62. The walls are perpendicular, and from twenty-five to forty feet in height. At some points, it contains veins of calcite, and small nests of fluor spar (No. 70). This rock is very thinly laminated in some of the beds, and its stratified character is everywhere to be seen. In a hill near the point where we struck the Lake, which was nearly two miles above the mouth of the Wisacodé, is an exposure of greenstone which passes into syenite (No. 71).

Between the lake-shore and the high greenstone ridge back of the bays above Grand Portage Bay, are four ridges, varying from one hundred and fifty to two hundred and fifty feet in height, the southerly one descending gradually to the Lake, with occasional spots of swampy ground intervening.

At the bottom of the first bay, proceeding toward the mouth of Wisacodé River, is a grayish-coloured amygdaloid (No. 52). It is shaly, and decomposes easily. The points of the bays, as far as the fourth, are composed of greenstone, and appear to belong to a heavy north-45°-east dike, which has been broken down and nearly carried away by the action of the Lake. From this point, to what I have called the Eastern Palisades, the shore consists mainly of amygdaloid, overlaid by metamorphosed siliceous slate. The cells of the amygdaloid are filled with laumonite, thalite, and other minerals. The amygdules are from the size of a pea to that of a hazel-nut. Thin seams of the same minerals are also found filling joints and cracks. The dip is southeast, at an angle of 12°, and the height of the exposures above the water-level varies from ten to fifteen feet. The line of junction between the amygdaloid and the metamorphosed slates is much broken and very irregular. At some localities the amygdaloid weathers into caverns, and many irregularly formed pillars

support the capping of altered slates. As the Eastern Palisades are approached, the sedimentary rocks become more bent and undulating, in consequence of the numerous narrow prismatic dikes which traverse them. The rock composing the Eastern Palisades (No. 57) is, in every respect, like that of the Palisades near Baptism River, as well as the metamorphosed siliceous slates of Wisacodé and Pigeon Rivers.

The Palisade rock here forms a point thirty-six feet in height, which projects into the Lake for the distance of one hundred feet. It extends back to the first high greenstone ridge in a tolerably level plain, covered by scanty vegetation. Like the metamorphosed shales below Bitobigungk, it lies between two trap ridges, and is traversed by narrow trap dikes, having different bearings, which do not appear to have caused much disturbance in the sedimentary rocks at the time of their eruption. Between this point and the mouth of Wisacodé River, the rocks exposed on the shore vary in height from three to twenty feet, and are composed, in the bottoms of the bays, of altered slates overlaid by bedded trap, and at the points, by the remains of a great north-45°-east dike (No. 58.) Immediately below the mouth of the Wisacodé, in the first bay, the shores are composed of No. 638.

Along the extent of coast just described, numerous narrow trap dikes traverse the bedded rocks, differing in composition and bearing. In the second small bay below the Wisacodé, a dike of greenish-coloured trap, bearing north 60° west, intersects the north-45°-east dike mentioned above. These dikes vary in width from three to twenty feet, and bear east and west, north and south, north 20° east, and north 45° west. Nos. 641 and 642 show the general character of the rock composing the dikes, most of which are shown on the Geological Map.

At the northeast end of the island, in Grand Portage Bay, is a narrow dike, bearing west 10° north.

At the point opposite the centre of the large island, in the cluster below Waswagoning Bay, is a dike bearing east and west, accompanied by a vein of calcite from two to three feet wide. In its course across the bay, the dike forms several rock-islands. A little below this is a heavy east-10°-north dike, which resembles No. 636. It imparts to the sedimentary rocks in near contact with it, much of its lithological character. This dike continues along the point to the projection opposite the northeast end of the island (No. 649). The island is composed, mostly, of No. 650, which bears east and west, and is concerned in the formation of most of the islands here. It crosses at the bottom of the bay and runs inland.

At Grand Portage Bay are two ancient lake beaches, the first one about one hundred yards back of the present beach, the other three hundred yards further back. The first one is, like all the present beaches, highest next the Lake, with a descent of several feet to the base of the second one.

The details of the Coast Section, from Grand Portage Bay to Pigeon Point, are given, in the following Report, by Major Richard Owen, who made the examinations.

Dr. J. G. Norwood.

Sir,—Having received instructions from you, on the 17th July, 1849, to take the canoe, with some of the men, and examine, in detail, the coast, from the mouth of

Pigeon River to Grand Portage Bay (and thence send some of the voyageurs across by land, with provisions, while you followed, on foot, the course of Pigeon River, from its mouth up), I herewith submit the following

REPORT.

Pigeon Cape, or Point, is formed by a trappean upheaval, the products of which have flowed, apparently, from fissures, having a strike or bearing usually somewhat north of east. It is not, however, a continuation of the nearest main trap ridge, the peak of which, rising a short distance northeast from the interior of Grand Portage Bay, you directed me, on a former occasion, to measure barometrically, and which I found to be six hundred and thirty-four feet high. That range, as you afterwards found, bears northeast and southwest, and forms the falls of Pigeon River, about a mile and a half from the "Mission," and is there two hundred and twelve feet wide.

The trap ridge constituting Pigeon Point, has withstood the wearing effects of time and the action of the water; and has formed, in conjunction with the slates, through which it frequently cuts, a strip of land, usually about half a mile wide, which stretches nearly four miles in length, from the mouth of Pigeon River, the latter flowing out on its north side. About three miles from the mouth of the river, where the trap range is partially interrupted, there is low shingle beach, extending across the peninsula, which here is only from two hundred to two hundred and twenty-five feet in width, and six feet above the lake-level of that year (1849). At this point, in a short time, no doubt, the shingle beach will disappear, shortening the cape about a mile, and leaving an island, similar to those found so abundantly in the Lake, in a bearing continuous from some of the numerous trap ridges or dikes of the north shore.

The above greenstone trap ridge has, on both sides, cut through slates, altering them, in many cases, considerably, and giving them a general dip, from the disturbing cause, of from 15° to 40°: about 40° south-southeast, near the extreme point of the cape, on its south shore, and northerly on its north shore; while the angle of dip is usually only from 15° to 18°, south-southeast, when the distance from the disturbing cause is greater, as it is at the points forming the east end of Grand Portage Bay.

This point consists of a southern spur from the main trap ridge, and is formed, apparently, by a lateral overflow. Where it terminates in the Lake, this sheet of ancient submarine lava seems to have flowed perpendicularly over the ends of the shaly rocks.

Near this point, the rocks are about ten feet above the Lake, and although somewhat aluminous, are more siliceous than those on the north side of Pigeon Cape, where the argillaceous character predominates: some, indeed, appear to be altered sandstones.

In addition to the greenstone ridge, there are several dikes on the peninsula, some having a nearly east-and-west direction, while others bear nearly north and south.

They vary in width from fifteen to twenty feet, and produce sometimes great

local disturbance, where they cut up through the slates, tilting them, occasionally, entirely on end.

These dikes are, usually, coarsely crystalline in the centre, but finer-grained near their junction with the slate, probably in consequence of cooling more rapidly and of being subjected to pressure from the adjoining slates. The slates, near their contact with the dikes, exhibit evidence of having been exposed to great heat, and occasionally even resemble, in texture, the volcanic dikes themselves; resuming however, gradually, their natural structure as the distance increases.

The dikes, sometimes, are composed of irregularly pentagonal and hexagonal columns, lying at right angles to the line of upheaval, at right angles, consequently, also, to the lateral cooling surfaces.

The accompanying map and section* (in which the height of the slates is, necessarily, exaggerated, to give a good idea of the general dip and local disturbances), will probably serve to convey some idea of these grand convulsions of Nature, which, however, as you are well aware, have to be seen in order to be appreciated.

The more minute details, beginning at the mouth of Pigeon River, and finishing at the Grand Portage, are given in the following "Notes from my Journal."

As it rained during the night, although we rose at 3h. 30m. A. M., we did not set out until 6h. 10m. The first point of importance, after leaving the mouth of Pigeon River, and following the coast in an easterly direction, is a dike of massive greenstone (No. 654). In the rear of this, when viewed from the Lake, a trap ridge is seen, about one hundred and fifty feet high, chiefly covered with birch and mountain ash.

About half a mile from the mouth, a basaltic-looking rock (No. 656), probably a metamorphosed clay slate, appears, from ten to fifteen feet high (the distances being estimated from the lake-level), with a vein of calcareous spar in the slate eighteen inches wide, besides two smaller veins; then bluff rocks, fifty feet high, of trap, with a north-and-south vein containing a gangue of argillaceous material (No. 657), and sulphate of baryta in its centre. The bluff terminates east in a trap dike, with shale (No. 658). The slate continues for a considerable distance, varying in height from five to twenty feet.

At the next point of note, we find fine-grained basaltic trap (Nos. 659 and 660), succeeded by trap, in bluffs twenty to twenty-five feet high, rising finally to one hundred and fifty feet.

These bluffs are, probably, lateral spurs from the backbone ridge; they occur at a distance estimated as somewhat more than a mile from the mouth, and the locality may be recognised by having, in large letters, the word ENINI scratched upon the rock, probably by some of the Grand Portage band of Indians, who, under the care of Catholic missionaries, have made considerable progress in reading their own language, printed in Roman characters.

The wind blowing too hard for the canoe, we had to put back some time; and when we again started, at 8h. 30m., A. M., and reached the same point, we soon observed another trap dike and overlying trap, one hundred and fifty feet high, run-

* See Pl. N.

ning northeast into the Lake. Next succeeded a fine-grained basaltic trap (No. 661), forty feet high; then a dike composed of coarse-grained trap in the centre and fine-grained trap adjoining.

The next place of importance afforded a coarse porphyritic trap (No. 662), containing crystals of felspar, sometimes two inches cube; then pebbly beach, with narrow trap coming to the Lake in three places, the last a considerable point, nearly three miles from the mouth. Here a dike of basaltic trap, fifteen feet wide (Nos. 663, 664, and 665), has carried up thirty-five or forty feet of slate on each side and altered it (No. 666). This dike continues several hundred yards. Next occurs a rock (No. 667), which may be termed a syenite, although there is very little quartz compared to the amount of felspar and hornblende.

Soon after, the shingle was so low that I could see across the cape, and, on stepping it, found the distance only about two hundred and twenty feet. Porphyritic trap succeeds the low shingle, traversed north and south, at one place, by a narrow dike. Then follows a small bay of shingle beach, and again trap, twenty-five to fifty feet high, large-grained and porphyritic. The ridge here rises to one hundred and fifty feet, or more, and then gradually descends to thirty, twenty, and ten feet. Finally, a shingle beach, with a few greenstone rocks, in place, at the extreme end, terminates Pigeon Point. After turning in a direction south of west, and again passing the low shingle beach, a trap dike occurs (supposed, from the distance and bearing, to be the same seen on the other side), altering slates on each side a long distance. Then succeeds a reddish-coloured rock (No. 668), even less syenitic than No. 667.

The apparently metamorphosed rock (No. 669) was succeeded for a long distance by shales, dipping 40° south-southeast, and exhibiting great signs of disturbance at one point, where a dike cuts through. Next follows some shingle beach; then a fine dike, twenty feet high, cutting through and altering slates, which dip as before. Then follows another dike, fifteen feet wide, overlying the slates, which dip 40° to the Lake, in a southwest direction. This must be about three miles from the extreme point, as it is in sight of the islands which front Grand Portage Bay, and about a mile east of a bay, known as Morrison's Bay, from its being the great fishing-station for a half-breed Indian of that name, belonging to the Grand Portage band.

We soon after passed the calcareous vein seen on the other side. It bears northwest and southeast. There were here also several smaller veins. Near this place, the altered slates began to assume a columnar appearance, the columns being at right angles to the dip. Two dikes soon after appeared as the cause of the great local disturbance here, for, in their neighbourhood, the slates were entirely tilted on edge. (Specimens Nos. 670 and 671 were taken from this spot.) Farther on, the slates continue altered, and after passing a small bay, an east-and-west dike of trap, which projects into the Lake, has tilted the slates on each side to a high angle; the dike is, as usual, about fifteen or sixteen feet wide, while the slates are fifty or sixty.

After crossing Morrison's Bay, the dip of the slates is reduced to 18° and 20° south-southeast; but at a point not very far from there, they are again upright for a short distance.

Then succeeds about a quarter of a mile of shingle beach, followed by a point formed of uptilted altered slates, traversed by a calcareous vein, eighteen inches wide, running northwest and southeast; then shingle, altered slates, a little shingle beach, and slates twenty-five feet high, not tilted quite so much as the last, and traversed by several veins from four to twelve inches wide.

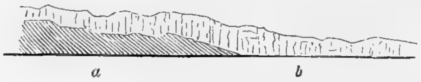
About one hundred and fifty feet back from the Lake, there are seen, soon after, perpendicular shaly rocks, forty feet high (No. 672), very little, if at all, altered. They have now become more siliceous than the former specimens.

Having, on a former occasion, walked along the large bay which succeeds, and there observed slates, I directed the canoe across to the next point, which is the trappean overflow or spur from the highest trap peak, already mentioned as being six hundred and thirty-four feet high. The underlying alternations of metamorphosed siliceous and argillaceous rocks here dip not from the spur or overflow (three hundred and seventy feet high), but from the main trap ridge, consequently south-southeast, except in the vicinity of a narrow four foot dike (No. 673). These altered rocks continue about ten feet high, overlaid by the greenstone trap, which has a rude bedding of the same inclination that they have, viz., 15° to 18° south-southeast. The direction or bearing of this trap ridge, as seen from the Lake, appears to be north-northeast and south-southwest. It is about three or four hundred yards across, at its termination, and seems to be an overflow which has acquired the same inclination as the rocks over which it has flowed, until it comes to the end of them, when the inclination has become vertical, or even over the perpendicular.

The altered rocks are again found (after turning the point), with about the same dip as on the other side, 15° south-southeast.

Some of the shales are light-coloured, and are composed of distinctly-rounded grains of quartz, like the lower beds of the sandstone series on St. Louis River. These beds are from two to twelve inches thick. The argillaceous beds cleave with great facility; but as the trap is approached, they become more compact, and assume a hornblendic character.

The overlying trap bed is shown in the subjoined section:



a. Slates and shales. *b*. Trap bed.

The remainder of this spur, where it reaches the shore, is shingle beach.

There appeared to be no changes worthy of note, between this point and our encampment, at the commencement of the Grand Portage Trail.

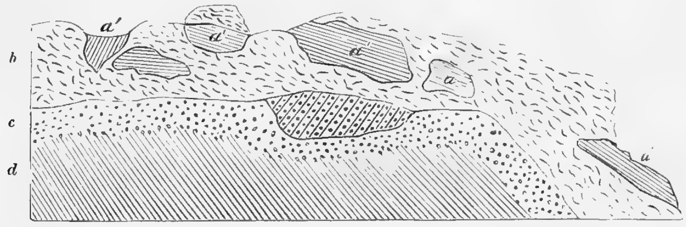
I regret that I had not an opportunity of returning to verify some of the details on this very interesting spot; but hope the above brief Report, in addition to your detailed description of the collected specimens, may aid in giving some idea of the general formation and geological character of Pigeon Point.

I am, sir, very respectfully,

Your obedient servant,

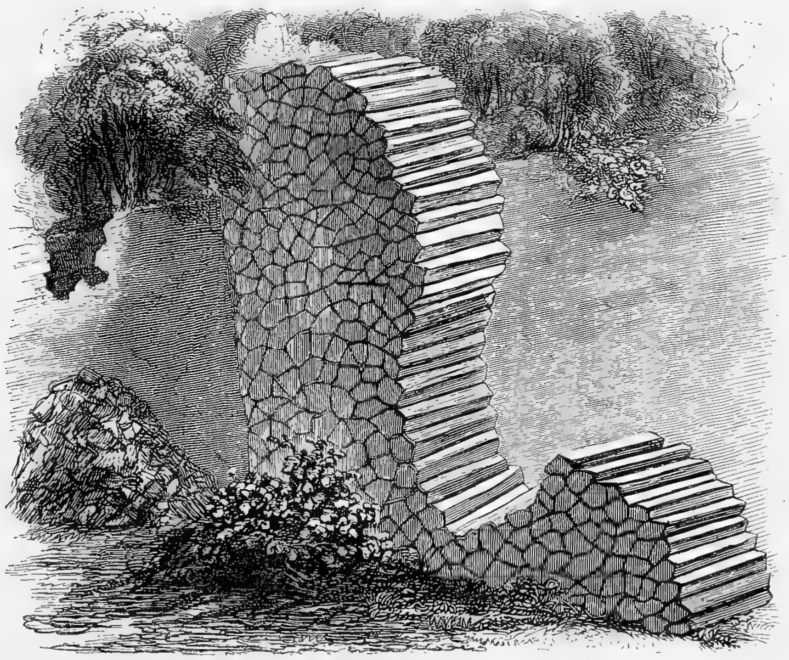
RICHARD OWEN.

The summit of the ridge nearest the bottom of Grand Portage Bay is composed of greenstone, which has been erupted through argillaceous slate. At the bottom of the hill the slate is unaltered, and dips 12° to 15° to the southeast. The greenstone has carried some large masses of slate with it, and completely enveloped many of them. Some of the enclosed masses are but little altered, while others are almost completely metamorphosed. The metamorphosis begins about twenty feet above the level of the first lake-terrace, and extends to the top of the slate, which mounts to within sixty-one feet of the summit of the ridge, which is two hundred and seventy-eight feet high. The width of the dike varies from seventy to eighty yards. Where the slates have become entangled in the trap, and separated widely



a', *a'*, *a'*, *a'*, *a'*. Slate entangled in trap. *b*. Greenstone. *c*. Amygdaloidal slate. *d*. Unaltered slate.

from the mass, the metamorphosis is most complete, the rock assuming the appearance of a compact hornblendic slate, but still separating in the cleavage planes. The colour is sometimes reddish, and at others bluish black, like slag. Many of



EXPOSED DIKE OF COLUMNAR BASALT, LAKE SUPERIOR.

the enclosed masses are amygdaloidal. The course of the dike is northeast and southwest. It cuts the long point on the lower side of Grand Portage Bay, and is

continued along the bottoms of the bays below, until it finally reaches Pigeon River. It is intersected in this distance, at various points, by narrow dikes, which contribute to the formation of the points between Grand Portage and Pigeon River. The last dikes differ, lithologically, from the one in question, and are easily traced across the slates and the great greenstone dike.

Near the west end of the ridge, one of the prismatic dikes, discovered by Major Owen on the shore of Grand Portage Bay, crosses it, bearing east and west. This dike is thirteen feet wide. Between the ridge and the Lake, the ground is low, and as the ridge is approached, the dike stands up in the woods like a wall, with all the regularity of masonry, as seen in the preceding sketch, by Major Owen. The prisms are nearly horizontal, and from a foot to two and a half feet in diameter. In addition to the two dikes discovered here by Major Owen, and which run due east and west, I found another in the woods, further west. It does not show itself on the lake-shore, but traverses the low grounds in the form of a great wall, fifty feet in height. It bears east 15° north (No. 646), and is sixteen feet wide. It finally enters the first high escarpment north of the Lake, formed by between seventy and eighty feet of slate, overlaid by a bed of trap. These dikes all cut across the subordinate ridges, and continue on to the main range.

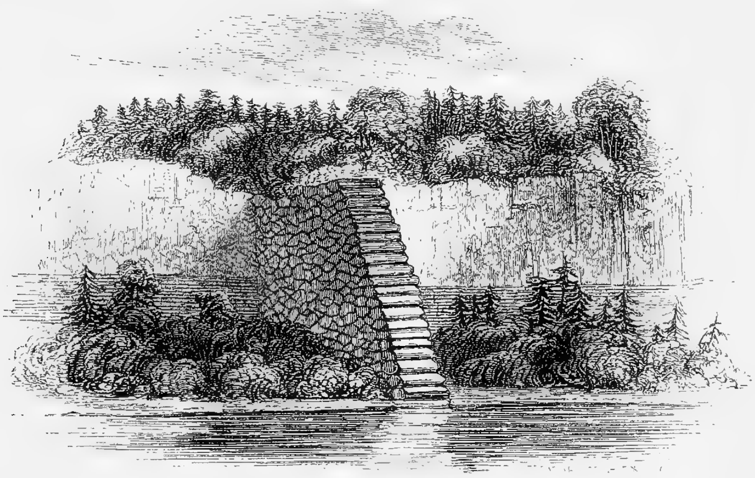
The valley of the first stream, a tributary of Pigeon River, which crosses Grand Portage, is bounded on the lake side by a high range of rocks bearing northeast and southwest, six hundred and fifty feet high, from which four other ranges are visible to the northwest, all having, apparently, the same bearing. From the summit of this ridge, four miles distant from the lake, the spectator commands an extensive bird's eye view, as far as the mouth of Pine River, and the ranges north of it, in Canada. This scene is well depicted by view 1, on Pl. 1, N., looking to the north.

From the top of another and higher ridge, southeast of the one we first ascended, looking south, we could see the Lake. The northwest side of all these ridges have mural escarpments, from one hundred and fifty to two hundred and fifty feet in height, the top rock being greenstone, and the bottom argillaceous and siliceous slates. Occasionally, fissures five or six feet in width are found in these ridges, through which the escarpments may be ascended. In most cases they have been occupied by spar veins, carrying oxide of iron, and their general direction is northwest and southeast.

Further west on the portage, large masses of greenstone are occasionally found resting on the slates, and several low slate ridges occur in the neighbourhood of the river. Where the portage strikes Pigeon River, the slates are unaltered, and dip southeast at an angle of 8°.

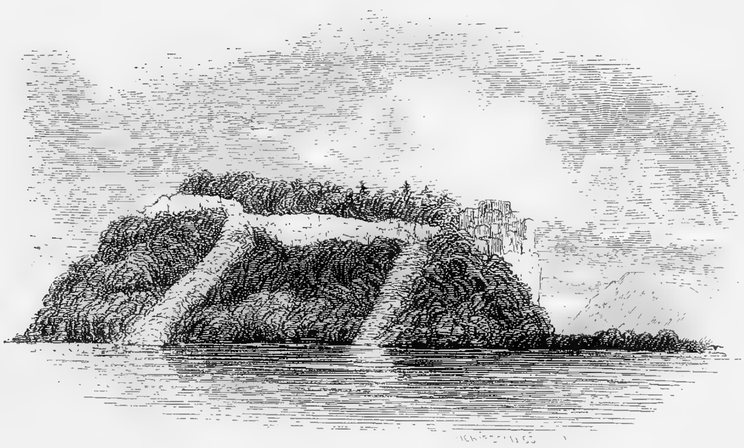
From the nature of the country it is not possible to trace many of the narrow dikes with certainty for great distances. It is believed, however, that most, if not all, of those seen on the lake-shore, traverse the ridges lying between the Lake and Pigeon River, and form the numerous spurs having a north-and-south bearing, and which, upon being traced to the high escarpments, are found to be formed by narrow dikes. At some localities they start from the lake-shore in the form of high, narrow walls, and crossing the low grounds, from which the bedded rocks have been removed by denudation, enter the ridges, cut through them, and are found pursuing

their course in the valley beyond. The next ridge is traversed in like manner. The following sketch of one of these dikes, as it starts from the lake-shore, will convey a much better idea of their general appearance than a written description.



EXPOSED COLUMNAR BASALTIC DIKE, LAKE SUPERIOR.

They vary in width from eight to sixteen feet, and are generally perpendicular, though some of them hade slightly. Thin veins of calcite and seams of steatitic material are occasionally interposed between the sides of the dike and the slate walls; and sometimes there are evidences of a slip or fault in the sedimentary beds. In many of the veins the slaty wall-rock is broken into small fragments, and disseminated through the calcite. When these veins branch off into slates, as is sometimes the case, they are broken into strings, and soon lose themselves. If they are continued sufficiently far, however, to reach another dike or bed of trap, they again become concentrated.

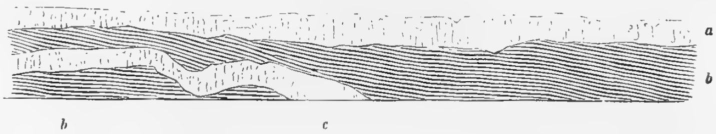


TRAP OVER SLATE, LAKE SUPERIOR.

Sometimes the slates rise in mural escarpments to the height of two hundred feet, and over these a bed of trap is imposed. Where the dikes have been broken

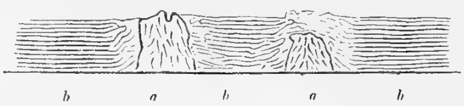
down on the slope or plain lying between the hills and the lake-shore, or in the valleys, their course, as before stated, can still be traced by the eye at a great distance, forming narrow ridges with abrupt sides, concealed in a great measure by the talus at the base of the hills, until they enter the naked escarpment of trap at the top, as shown in the preceding sketch.

Several narrow dikes often occur in the space of one hundred yards; and some of them send off lateral intrusions between the slate-beds. On the north side of Pigeon Bay, the annexed section occurs, illustrative of the manner in which the



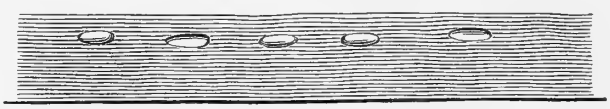
a. Overlying trap-bed. *b, b.* Slates. *c.* Lateral injection of trap.

slates of this region alternate with trap-beds, and exhibits at the same time a lateral injection from a neighbouring dike. A short distance from this point, are several intrusions of trap from below, through fissures in the slate, one of which does not quite reach the present surface, as shown in the subjoined section. The slates are but slightly disturbed, and then only in the immediate vicinity of the dikes. In



a, a. Trap. *b, b, b.* Slates.

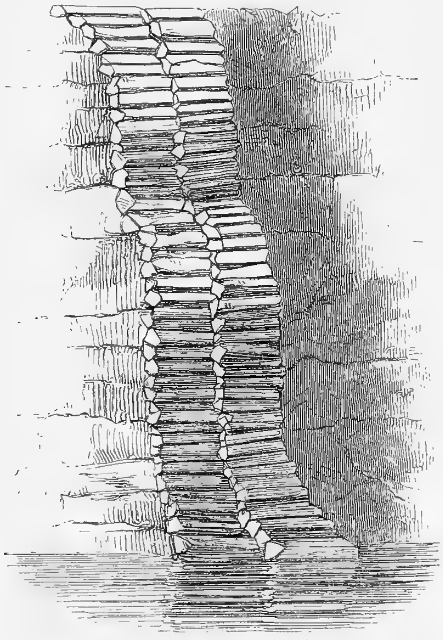
these same beds are many singular spheroidal concretions, bearing considerable resemblance to septaria. They appear to occupy a certain position in the thinly-laminated slates, as shown in the following section, and are composed of a grayish-



coloured material, which decomposes easily, and leaves long lines of cavities in the vertical walls of the lake-shore. They resemble in some respects the concretions in the altered slates of Passabika River, but differ from them in the contents of the spheroids.

A few of the prismatic dikes in this vicinity exhibit the appearance shown in the following sketch by Major Owen. The dike represented is on the lake-shore, and projects ten or twelve inches from the face of the escarpment. About the centre, the prisms are divided by a vertical seam of steatitic material, from two to three inches thick, with thin scales of calcite next the ends of the prisms. Many of the angles of the prisms on different sides of the seam coincide, but, as the greater

portion of them do not, I think it most probable that the dike, as it now exists, is due to two eruptions, the fissures having been reopened after the first filling had become partially or wholly cooled and consolidated. I could discover, however, no difference in the composition of the rock on different sides of the seam.



ENCLOSED DIKE OF COLUMNAR BASALT, LAKE SUPERIOR.

21. *Pigeon River.*—Between the mouth of Pigeon River and the first falls, the only rocks exposed are alternations of siliceous and argillaceous slates, which are seen in the banks of the river, about half a mile above the old Mission. The falls are about a mile and a half above the mouth, following the windings of the stream. The river, which is about twenty-five yards wide above the fall, descends perpendicularly sixty feet. Immediately below is a deep gorge, which soon contracts to fifteen or twenty feet in width, with mural walls, between which the stream chafes its way for the distance of two hundred yards. The sketch on the next page, by Major Owen, taken from a point a short distance below the fall, exhibits the slate-beds at the upper end of the gorge, with the overlying trap.

The rock over which the water falls is a compact greenstone (No. 1), and is a continuation of the dike which passes back of Grand Portage Bay. On the lower side of the dike, the slate through which it cuts is altered for some distance. About thirty-six feet from the trap, it is but slightly changed, except where it is intercalated with a bed of basaltic rock, when it assumes something of a trappous character (No. 2). Twenty-five feet from the dike, it is still more altered (No. 4), and in still nearer proximity, some of the beds are converted into a schistose quartz-rock. The width of the dike is two hundred and twelve feet; and its height above the fall, in the direction of Grand Portage Bay, is one hundred and ninety-four feet. It bears north 45° east. The slates, which, with

the intercalated and overlying trap-beds, ascend nearly to the summit of the ridge, dip southeast, at an angle of 4°. Overlying the slates, on the flank of the ridge, is a bed of crystalline greenstone (No. 5), the same that is found capping them over a large district of country. The junction of the slates with the green-

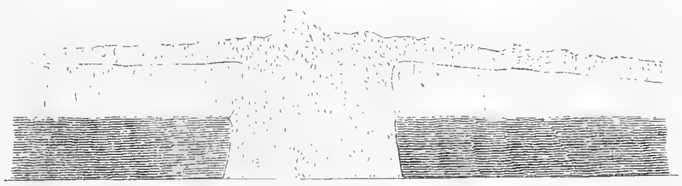
GORGE AND FALLS OF PIGEON RIVER.

stone is exhibited, by the first section on page 407, by Major Owen, of an escarpment, a short distance above the fall. In the drift on the summits of the ridges, many fragments of red sandstone (No. 6) occur.

About one mile further up the river, is a small fall, where the exposure of the slaty beds is sixty feet thick, and capped by a bed of greenstone. Below this fall,

the slates have no perceptible dip. Between the two falls, the argillaceous beds are extremely fissile (No. 12), for the height of fifteen or twenty feet above the river-level, and then become gradually more and more altered, until they assume a columnar structure as the greenstone-bed is approached, as shown in the second section on this page.

The section below is among the very few where any certain connexion was seen between the overlying trap-beds and the large dikes. The dike, which traverses



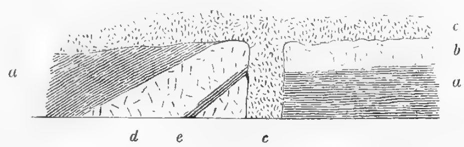
a. Argillaceous slate. *b.* Metamorphosed slates. *c.* Bed of greenstone. *d.* Greenstone dike.

the slates at this place, and sends off the sheets which overlie them, has produced little or no disturbance, except at the junction. A section of the rocks here, in ascending order, is as follows:

1. Quartzose schists (No. 7).
2. Clay slates (No. 8), alternating with quartzose layers.
3. Hornblendic schists (No. 9).
4. The same rock (No. 10), passing into greenstone.
5. Greenstone (No. 11), forming the dike and the overlying beds.

The thickness of the metamorphosed beds in this section is forty-five feet. Below the dike, the beds have no perceptible dip; above it, they dip to the northwest, at

a. Argillaceous slate.
b. Metamorphosed slate.
c, c. Greenstone, dike and bed.



d. Quartzose porphyry.
e. Spar vein.

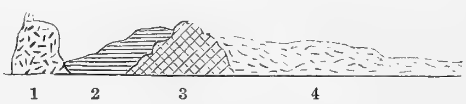
an angle of 5°. About two hundred yards further up stream is another dike, which appears to have been erupted at the same time with the one last-named, as

the overlying trap-bed proceeds from both of them, as shown in the preceding section.

On the northwest side of this dike a fault occurs, which brings up an exposure of quartzose porphyry, resembling in all respects the rock forming the Great Palisades, and also the metamorphosed porphyritic beds below Hat Point. Some of the beds, when struck with the hammer, ring like clinkstone. The slaty beds above it dip to the northwest, and are overlaid by greenstone, as shown in the section, without any appearance, however, of the metamorphosed columnar beds seen on the southeast side of the dike. The quartzose shales are traversed by a vein of calcite, seven feet in width, which crosses the river to the Canada shore, where it is contracted to four feet. Its course is northwest and southeast, across the line of strike.

A mile and a half above this place, the river is crossed by a dike of fine-grained greenstone, bearing east and west, and causing a perpendicular fall of nineteen feet. Above this is a rapid, which descends eleven feet in fifty yards, making in all a fall of thirty feet. The whole exposure of rock, which is traversed by numerous thin veins of calcite, is thirty-four feet.

About nine miles above the mouth of the river, there is a rapid, made by a ridge of slaty greenstone (No. 42), flanked by altered slates below, and a bed of greenstone above. This ridge is composed, in part, of red siliceous porphyry (No. 41). The hills, on both sides of the river, are between three and four hundred feet in height. The fall is eleven feet in forty yards, in a succession of little cascades. The rock exposure is shown in the following section:



1. Quartzose porphyry. 2. Argillaceous slates. 3. Slaty greenstone. 4. Hornblendic rocks.

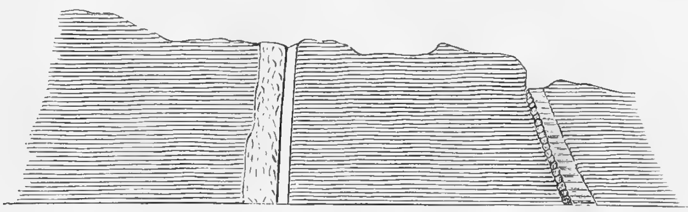
After passing this fall, the ridges become more frequent, and rise between three and four hundred feet above the river-level, the high valleys between them bearing a heavy growth of timber, among which are many large poplars and white birch. On the tops of the ridges, red clay and marl beds occur. Beyond this, the slate-beds begin to thicken, exhibiting escarpments in the river-banks, from forty to fifty feet in height, and mounting up the slopes of the hills, until the overlying greenstone-bed is reached. Throughout all this distance the bedded rocks are traversed, at irregular intervals, by narrow dikes, similar in composition, and having the same bearings, as those seen on the lake-shore.

Between the mouth of Arrow River and the Great Cascades, after ascending from the valley of the river, the country is rolling, and covered with very large poplar, spruce, and birch. The river in this distance presents a succession of rapids and small cascades, with short intervals of gentle current between them.

The Great Cascades of Pigeon River are about one mile below the west end of Grand Portage, once the site of "Fort Charlotte," for many years the most important post of the "Northwest Fur Company." The scenery at the Cascades presents the singular combination of wild grandeur and picturesque beauty, with an aspect

the most dreary and desolate imaginable. In the distance of four hundred yards, the river falls one hundred and forty-four feet. The fall is in a series of cascades through a narrow gorge, with perpendicular walls, varying from forty to one hundred and twenty feet in height, on both sides of the river. The gorge is from fifteen to thirty feet in width, and crooked, presenting numerous angles, around which the foaming waters fret their way with arrowy swiftness, plunging down abrupt slopes, or falling in beautiful cascades.

The slate, of which there is a fine exposure here, dips south-southeast, at an angle of 8°; and including the beds of the next mile above, is about two hundred and fifty feet in thickness. The lower beds (No. 44) are unaltered and very fissile. In the vicinity of the trap dikes, however, they are highly metamorphosed (No. 45). Two dikes cross the river here; one a coarse-grained hornblendic greenstone (No. 46), which disintegrates easily, and bears northwest; the other a prismatic dike of fine-grained greenstone, bearing north and south. The following figure exhibits a section of the rocks at this place.

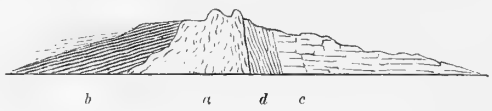


a, a. Argillaceous slate. *b.* Trap dike. *c.* Vein of calcite. *d.* Prismatic dike.

The dike, No. 46, is accompanied by a wide vein of calcite (No. 47). Where it touches the water on the American side, which is about forty feet below the highest exposure, it is somewhat broken. The wall-rock is trap (No. 48) on one side, and slate on the other. From the bottom of the lower cascade to the top of the slates at the head of the falls, the height is one hundred and fifty-nine feet. For the distance of three quarters of a mile above this, the river has little or no current, several rapids then occur, and the stream flows between slate hills until the west end of Grand Portage is gained.

Opposite the site of old Fort Charlotte, Pigeon River is thirty yards wide, and the rocks are displayed on both shores, dipping southeast at an angle of 8°. In ascending the stream, the next rock exposure is at the second portage, counting Grand Portage as the first. At this place a greenstone dike, one hundred and sixty-eight feet wide, crosses the river, bearing northeast and southwest, and accompanied by a vein of calcite. On the northwest side, the trap disintegrates easily, and there is some appearance of a breccia between it and the slate. There is a fall here of forty-one feet in three perpendicular cascades. Including the rapids above, the fall is fifty-five feet. Above the falls, the dip of the slate is northwest 8°. Below, is a narrow gorge cut through the greenstone dike, and the slates in contact with it are much altered, and the dip reversed to the southeast, at an angle of 17°. The section on page 410 shows the disposition of the rocks at this place. The ridge made by the dike here is the most northwesterly one in the Grand Portage range.

The slates on the northwest side of it, appear to be overlaid for some distance by trap, and some of the beds are changed to a compact hornblendic-looking rock. The portage is five hundred and ten paces long.

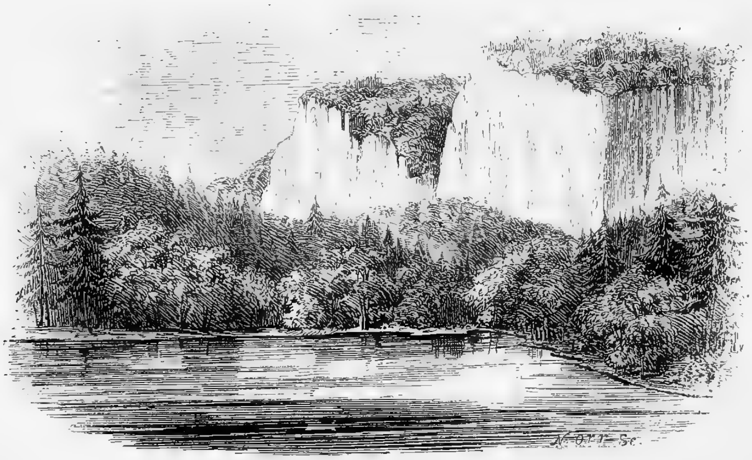


a. Greenstone. *b.* Slate. *c.* Metamorphosed slates. *d.* Slates with breccia.

The third portage of Pigeon River is six hundred and thirty paces long, and passes over a very low ridge, formed by a greenstone dike traversing clay slate. There are forty-eight feet of clay slate here, a portion of which, in proximity with the dike, resembles slaty hornblende.

The fourth portage is seven hundred and fifty paces long, and is made to avoid a rapid, in which no rock *in situ* was seen, nor is any exposed in the low ridge over which this portage passes. Between the third and fifth portages there are no rock exposures; both sides of the river being bordered by extensive swamps, which extend back to high greenstone ridges on the American side.

The fifth portage is two thousand two hundred paces long, and passes over low ridges, composed of clay slate, somewhat altered at some places, and highly metamorphosed at others. Toward the upper end the slate is overlaid by greenstone, and occasional large fragments of slate are seen enveloped in the trap, which appear as though they had been partially fused.



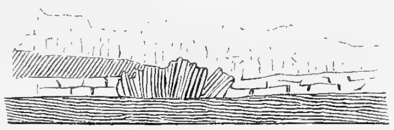
ESCARPMENT OF SLATE, LAC DU COQ.

At the lower end of Lac du Coq, where this portage terminates, the rocks are clay slate with hornblendic beds, overlaid by greenstone. The outlet of the lake is between high vertical walls. The summit of the precipice on the Canada side is three hundred and six feet above the lake-level, with a wide talus, one hundred feet in height at the base; on the American side the escarpment rises from the water to the height of ninety feet. The range here is composed of a number of

broken ridges, all with mural escarpments looking northwest, as is shown in the preceding sketch.

The principal rock is argillaceous slate, the upper beds of which are much altered, and overlaid by a tough, coarse-grained greenstone, which disintegrates easily when exposed to the weather, and falls to a dark yellow earth. As a general remark in relation to this rock it may be said, that as the surface of the bed is approached, it always becomes coarser, more crystalline, and weathers more easily.

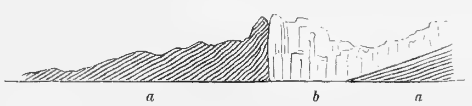
The rocks at this place show a very regular gradation from clay slate to hornblendic slate, and from that rock to common greenstone and syenite. Nos. 35, 36, and 37, show the alterations produced in the lower rocks by the greenstone. No. 38 is the lowest slate, and nearly or quite unaltered. No. 39 is within a few feet of the overlying rock, and No. 40 in immediate contact with it. Where Nos. 35 and 40 come together, there appears to be a commingling of the rocks, as though the lower rock had been broken up and partially fused by the trap. Where the contact is exposed in the escarpment, the metamorphosed rock assumes the semi-columnar structure of the trap. In the first hill southeast of the lake, the upper slate-beds have been elevated at a high angle by an injection of trap, as shown in the following section.



a, a. Slate. *b.* Trap injection. *c.* Overlying trap.

Between the range which crosses here, and the one to the southeast, the distance is from ten to twelve miles, and it is in this valley that the swamps mentioned above occur. On the borders of the lake the trap ridges are finely displayed, and the relations of all the rocks shown in the most satisfactory manner in the numerous escarpments of both shores, all of which bear a great resemblance to those represented in the sketch taken at the outlet of the lake.

The sixth portage is five hundred and fifty paces long, and leads to Moose Lake, where the Hudson's Bay Company have a winter house. A great many large fragments of slate occur on the portage, but no rock was seen *in situ*, the density of the forest and undergrowth being so great as to render explorations beyond the portage path almost impracticable. Southwest of the lake a greenstone ridge was seen, which, from its bearing, must cross the portage, and it is accordingly so laid down



a. a. Slates. *b.* Hornblendic rocks.

on the map. On the borders of the lake the rocks are principally schistose. The lowest rock seen was a very compact, fine-grained, hornblendic slate, overlaid by hornblende rock to the height of one hundred and fifty feet. As the east end of

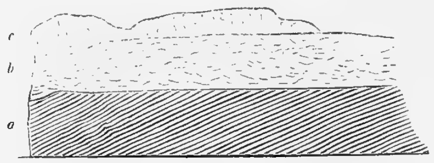
the lake is approached, in descending, a very decomposible hornblendic rock abuts against the more compact rock, and, dipping to the southeast at an angle of from 3° to 5°, disappears as the portage is reached.

West of the house, some good exposures occur, and near the west end of the lake are several high mural escarpments, on the American side, resembling those seen on Lac du Coq.

The seventh portage is one thousand and thirty-five paces long, and leads to Lower Lily Lake. It passes over a ridge, showing altered clay slates on the southeast side, and hornblendic-looking rock at the termination of the portage. The hill is sloping and densely wooded. On the American side of the lake are some high mural precipices, like those already described.

The eighth portage is two hundred and thirty paces long, and terminates at Upper Lily Lake. On this, as well as the preceding portage, numerous large boulders of granitic rocks were seen.

The lower rock at Upper Lily Lake is an altered argillaceous slate (No. 32), which rises to the height of eighty-nine feet above the lake-level. Above this, No. 33 occurs in thick beds, the rock becoming gradually more and more coarse and crystalline, until it graduates into the top rock of the ridge (No. 34). There is, however, a well-marked line of demarcation between Nos. 33 and 34, sixty-three feet above the top of the clay slates. No. 34 recedes from the main escarpment in thick ledges, and reaches the height of three hundred and sixteen feet above the water-level. It is exceedingly tough, and breaks with a concentric fracture. No.



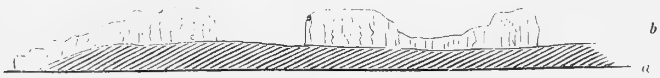
a. Argillaceous slate. *b.* Greenstone. *c.* Porphyritic greenstone.

33 weathers into mural precipices, and presents something of a columnar structure. The slates dip east-southeast at an angle of from 5° to 8°.

The ninth portage is three hundred paces long, over low ridges of greenstone passing into syenite. It leads to Hill Lake. This lake is about seven and a half miles long, and varies from a quarter to half a mile in width. It is a beautiful sheet of water, and lies completely embosomed amid high rocky hills, some of which slope down to the water's edge, while others present mural escarpments, between two and three hundred feet in height. The margin is skirted by a dense forest at every point. This lake lies between two trap ridges in its whole length, and consequently its long diameter conforms to the general bearing of the range, which is east and west.

The tenth portage is six hundred and forty paces long, and leads to Watab Lake. The rock exposed on it is a tough, compact greenstone, which appears to lie in tabular masses. At the lower end, next Hill Lake, it is rather coarse and crystalline, and at the upper end, fine-grained and more compact. Along the American

side of Watab Lake, are a number of perpendicular escarpments of No. 30, overlying argillaceous slate (No. 32). The slate is somewhat altered near the east end of the lake, but to what depth it is impossible to say, as the junction is hidden by a talus. The following section exhibits three of the principal escarpments on the



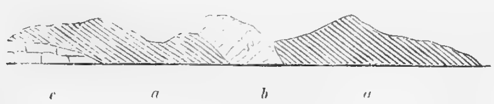
a. Argillaceous slate. *b.* Hornblendic rock.

American side of the lake. In general, the high mural walls here bear the greatest resemblance to those seen on the shores of Lake Superior, near Hat Point, and below Waswagoning, where the argillaceous and siliceous beds are overlaid by beds of greenstone, as shown in the subjoined section of one of the points of Waswagoning Bay.

a. Argillaceous slate. *b.* Greenstone.

Further west, on the shores of Watab Lake, some of the slate-beds immediately under the trap are altered into a very compact rock, with a semi-crystalline structure, while other beds would make good roofing slates (No. 31). Near the west end, the slates descend to the water-level, while the overlying beds form an escarpment, over three hundred feet in height. Several small ponds, connected by a narrow stream, which is the commencement of Pigeon River, lead to the next portage.

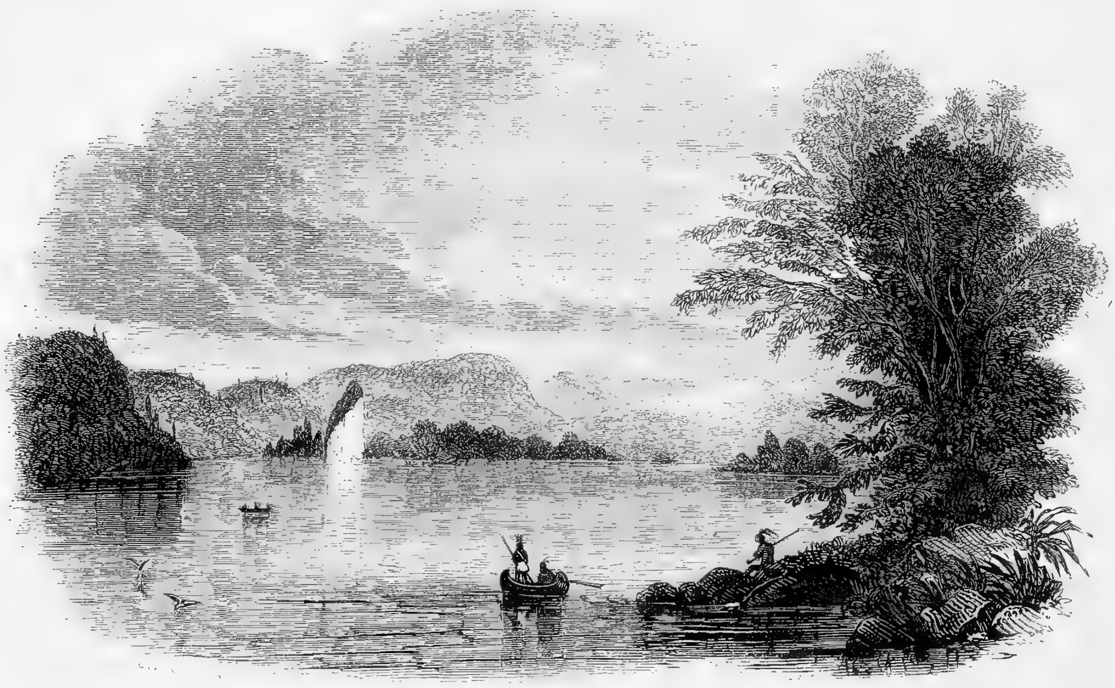
The eleventh portage is three thousand three hundred and fifteen paces long, and terminates at Mud Lake, the source of Arrow River, or, more properly, the east branch of Pigeon River. The portage passes over four low ridges, with swampy dells between them. The path is rendered rough and somewhat difficult, by numerous fragments of rock, which are scattered over it throughout its whole extent. The rocks exposed on this portage are shown in the annexed section. Near the



a, a. Argillaceous slate. *b.* Hornblendic rock. *c.* Slaty greenstone.

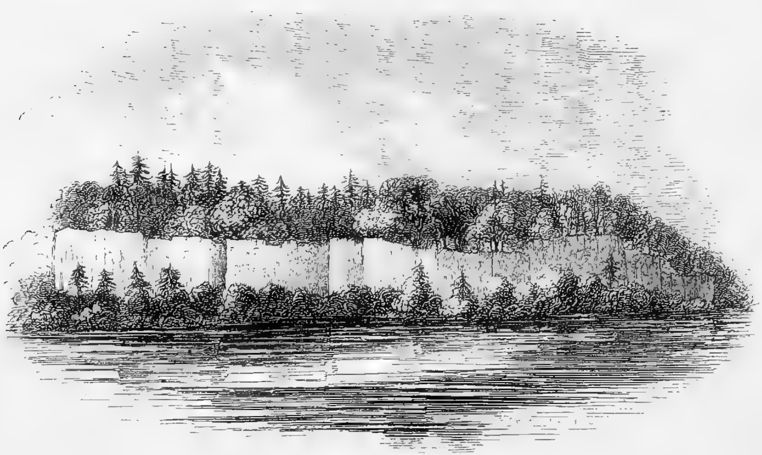
lower end is a sloping ridge of very thinly laminated argillaceous slate, which is exposed in low knolls and ridges for nearly half a mile, where it is associated with a bed of fine-grained hornblendic rock, and overlies or abuts against a coarsely crystalline greenstone. Beyond this the slates continue, until, near the upper end of the portage, they are underlaid by slaty greenstone, which passes into syenite. The slate ridges have gentle slopes, and in the small valleys between them ponds occur. Several springs, also, were noticed in these valleys,—a somewhat rare feature in this region.

The hills west of the lower end of Mud Lake are highly characteristic of much of the scenery of this portion of the District, and are accurately represented in the



HILLS OF SLATE, MUD LAKE.

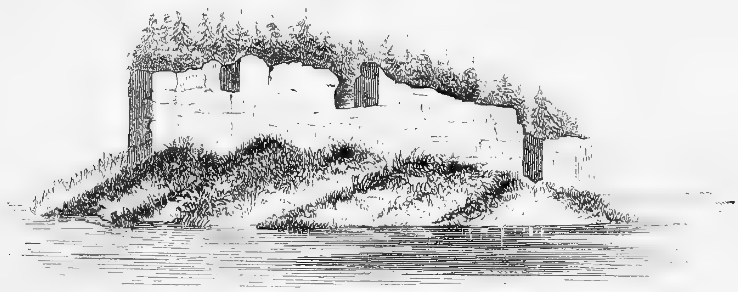
annexed sketch, by Major Owen. The slope of all these hills and ridges is to the southeast, the northwest sides being abrupt, or presenting high mural escarpments, with a talus at the base, frequently reaching from a third to half the height of the



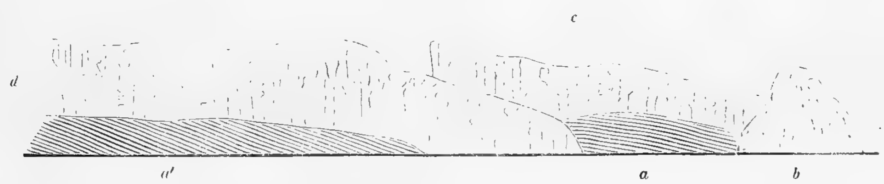
ESCARPMENT AND TALUS OF SLATE.

hill. Many of them occur on the shores of this lake, like the one represented in the preceding sketch.

Another example of a slate escarpment, with its talus, is exhibted in this cut.



The long point below the mouth of Arrow River is composed of a fine-grained hornblendic rock, with a slaty structure. It splits into thin layers, and is regularly jointed. On the gentle slope to the lake, where it is bare, it presents the appearance of a tessellated pavement. At the west end of the lake is a ridge four hundred and fifty-nine feet in height, the lower part of which is composed of argillaceous slate (No. 25). It dips southeast, into the side of the ridge, at a high angle. East of the slate-beds is a high ridge of syenite (No. 26), which extends to the margin of the lake, and forms mural precipices on the hillside. The upper part of the ridge, and near the hill over which the portage to Wisacodé River passes, the rock becomes fine-grained, and is jointed (No. 28). The succeeding ridge, which comes to the lake opposite the point above the mouth of Arrow River, is finer-grained and presents a slaty structure. It resembles slaty greenstone (No. 29). The following section illustrates, partially, the relations of the rocks here.



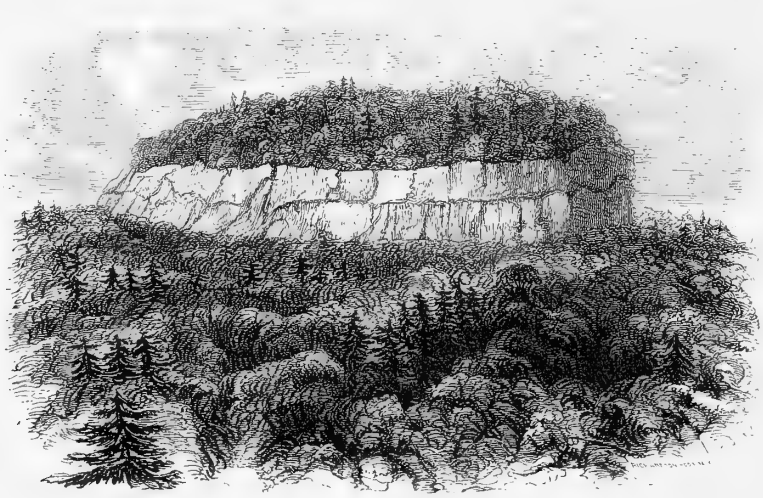
a. Clay slate. *b.* Syenite. *c.* Porphyritic greenstone. *d.* Hornblendic rock. *a'.* Slaty greenstone.

About a mile from the east end of Mud Lake, a small stream comes in, on the south side, and immediately west of it the portage begins which leads to a small lake tributary to Wisacodé River. The portage is about a thousand yards long, and crosses a ridge over three hundred feet in height. The stream just before entering the lake has a fall of sixty feet, in a series of beautiful cascades.

At some points the high ridges have a long slope to the lake-shore, covered with vegetation, which, with the talus at the base, conceals the rocks nearly to the summit, when they mount up in high escarpments, as represented in the sketch, by Major Owen, on page 416.

The twelfth portage is four hundred and forty paces in length, and leads over a low ridge, with numerous boulders of syenite, gneiss, and granite, scattered over it, to Ashawiwisitagon Lake. The ridge is composed of a syenitic rock (No. 24), underlying hornblendic slates, at the west end. On the shores of Ashawiwisitagon Lake, there are constant exposures of metamorphic slates, in low ledges, rising only

a few feet above the water-level. The last high mural precipice seen along the boundary line was near the lower end of this lake. On the American side is a



LONG, WOODED SLOPE AND ESCARPMENT OF SLATE.

ridge of syenite, four hundred feet in height, with a rounded outline and rather gentle slopes.

The thirteenth portage is five hundred and forty paces long, and leads over the dividing ridge between the tributaries of Lake Superior and those of Hudson's Bay to Mountain Lake. The rock forming the summit of this ridge is syenite, associated with massive hornblende. On the long point which projects into Mountain Lake, near the termination of the portage, the rock (No. 13) is schistose, and alternates with thin flinty layers. About a mile below this point, on the north side of the lake, is a low exposure of granite (No. 14) which slopes down to the margin of the lake. It is in low bosses, from ten to thirty feet in height, which are bare, or only covered with mosses and lichens. Back of this is a high ridge, bearing east and west, which ascends by a series of steps or plateaus, covered principally with mountain ash and small maple. About one-fourth the height of the ridge is a granite exposure, in which masses of hornblende rock (No. 16) were found completely enveloped. Still higher up, where the hornblende rock (No. 17) is traversed by small granitic veins, it becomes somewhat altered in character, and resembles diallage rock (No. 15). The top of the ridge is composed of coarsely crystalline hornblende (No. 17). This exposure, like the one on the dividing ridge, shows clearly the evidence of having been subjected to igneous action since its upheaval. I think it highly probable that it had a schistose structure prior to the eruption of the granite. On the top, many large, weather-worn fragments of granite occur, but no vein of that rock was seen. The outlet of Mountain Lake, which may be called the source of Rainy Lake River, is from thirty to fifty yards wide, but at its entrance into Flint Lake it is contracted to twenty feet, by a sand point, which extends out from the eastern end of that lake.

On the northwest shore of Flint Lake is an exposure of slaty hornblende (No.

18), the seams and joints of which are filled with imperfectly agatized quartz, chalcedony, and iron ore. The bearing is northeast and southwest, and the dip southeast, at an angle of 7°. A short distance below this is an exposure of quartz rock (No. 19), with seams of quartz running through it. The ridge immediately south of this is composed of hornblendic rock, like that seen on the dividing ridge. It forms perpendicular escarpments on the lake-shore, and is very fissile and decomposible. The annexed section shows the relations of the rocks at this place. A

a. Slaty hornblende. *b*. Hornblende rock. *c*. Quartz rock.

short distance beyond this the hornblende dips to the northwest, is much contorted, and contains numerous thin seams and intercalations of oxide of iron.

About one-third the distance from the lower to the upper end of the Lake, is a ridge of siliceous slate (No. 231), somewhat chloritic, and rising to the height of one hundred and fifty feet above the level of the water. It bears northeast by east and southwest by west. I could not discover the stratification, unless it agrees with the cleavage, which is 55° south of east. The direction of the joints is 35° north of west.

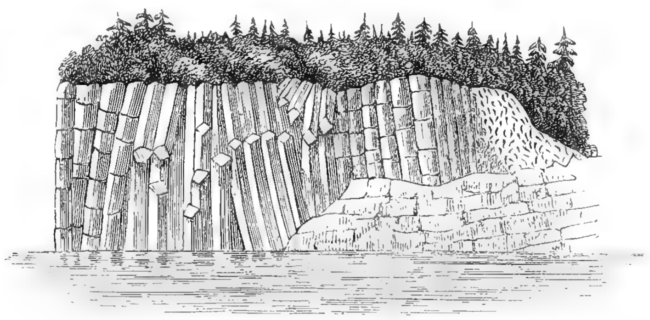
At the bend of Flint Lake a ridge of hornblendic rock occurs, massive in some parts, and schistose in others. The schistose portion (No. 22) has intercalations of flinty seams and thin layers of iron ore. The hornblendic rocks here, like those seen north of Mountain Lake, have been disturbed by granitic protrusions (No. 21), large masses of the hornblende (No. 20) being enveloped in the granitic rocks. The syenitic granite rises in rounded ridges to the height of from one hundred and fifty to two hundred and fifty feet. It is rather coarse and felspathic, and weathers with a remarkably rough surface, the other constituents disintegrating, and leaving the quartz standing out in relief. On some of the hills the granitic rocks appear in sloping tabular masses, as though they had been deposited in successive beds, like some of the trap overflows.

Between Flint Lake and Lake Saganaga, the rocks are all granitic, and resemble those already described. The stream which connects these lakes is divided into numerous channels, at some points, which flow around the granitic knolls, and occasionally cut gorges through them, with numerous cascades and picturesque falls.

This range, continued in a southwesterly direction, would pass in the line of the Missabe Wachu and the Pokegoma Falls of the Mississippi.

In conclusion, I may here remark that there is perhaps no extinct volcanic region in the world, where trap and other igneous intrusions can be studied to better advantage than in the country bordering on the northwest shore of Lake Superior. Not only are the vertical dikes numerous and conspicuous, but there are abundant examples of overflows, as well as interlaminated insinuations, producing all degrees of metamorphosis on the adjacent strata, graduating from mere

induration of the beds to complete obliteration of stratification and sedimentary origin, so that the beds of deposition become confounded with the igneous masses that have invaded them, and produced such extraordinary changes.



BASALTIC COLUMNS, RESTING ON SEDIMENTARY ROCKS, NORTH SHORE OF LAKE SUPERIOR.

COLONEL WHITTLESEY'S REPORT.

GEOLOGICAL REPORT

ON THAT PORTION OF

WISCONSIN

BORDERING ON THE

SOUTH SHORE OF LAKE SUPERIOR.

SURVEYED

IN THE YEAR 1849,

UNDER THE DIRECTION OF

DAVID DALE OWEN,

UNITED STATES GEOLOGIST.

BY CHARLES WHITTLESEY,

HEAD OF SUB-CORPS.

TO DAVID DALE OWEN, M.D.,

UNITED STATES GEOLOGIST.

Sir: In compliance with your instructions, bearing date the 30th April, 1849, I herewith submit a Report of the Geological Survey made by me in that part of Wisconsin bordering on Lake Superior, and lying between the Michigan boundary and the Bois Brulé River, and the sources of the streams flowing into Lake Superior from the south.

Yours, &c.,

CHARLES WHITTLESEY.

COLONEL WHITTLESEY'S REPORT.

CHAPTER I.

SECTION I.

GENERAL GEOLOGY OF THE DISTRICT.

THE accompanying map* and section are intended to represent, at one glance, the principal features in the geology of this region. The extent, elevation, and relative thickness of the various formations, as well of solid rock as the looser earthy deposits, will there appear in a more compact and intelligible form than I could give them by written descriptions, however elaborate.

There are four formations or great classes of rocks shown on each section. These all appear in the same order of succession, reckoning from the Lake southerly, and may be grouped thus:

1. SEDIMENTARY.
   - *a.* Red sandstone.
   - *b.* Black slate.
   - *c.* Conglomerate.
2. TRAPPOUS ROCKS, OR THOSE OF VOLCANIC ORIGIN.
   - *a.* Black and red amygdaloid and greenstone trap.
   - *b.* Augitic, hornblendic. and felspathic rocks, embracing syenite and granites of the same age.
3. METAMORPHOSED ROCKS.
   - *a.* Hornblendic slates.
   - *b.* Iron slates.
   - *c.* Black slates, in large, thin, rectangular sheets.
   - *d.* Talcose slates, with quartz.
   - *e.* Slaty quartz.
4. GRANITIC.
   - *a.* Syenite, and
   - *b.* Granite, occupying the country south of the mountain range or uplift, and are the oldest rocks seen.

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* The geological features of the map here alluded to have been transferred to the general Geological Map. The coloured sections accompanying this Report are Nos. 1, 2, 3, and 4 W.

Since these four systems of rocky beds and masses underwent their last disturbance, the superficial materials have been deposited, reaching from the lake-level, and from unknown depths below, up to the highest summits, 1282 feet above the Lake, or 1906 above the Ocean. I do not feel at liberty, on account of the total absence of fossil shells, to place these materials in any recognised division of the Tertiary. They are doubtless of the *Quaternary* epoch, and are connected in their origin with sudden and recent movements and upheavals on the north shore, attended by intense heat, by which causes the ancient waters were powerfully agitated and charged with mud and coarse gravel.

These deposits admit of but two subdivisions:

a. Red clay.
b. Boulder drift, coarse sand, and gravel.

This distinction is based, however, more upon the different materials that compose the beds, than upon a difference of age; for it is most probable they are cotemporaneous.

a. Red Marly Clay.—This is a fine-grained, homogeneous marly sand, cemented by argil or clay, with well-defined horizontal lines of lamination or deposition; containing, but very rarely, pebbles of granitoid, trappose, sandstone, conglomerate, or slate rocks. This constitutes the shore or lake bluffs most part of the way from the Montreal to the Brulé; the red sandstone, on which it rests, showing itself occasionally beneath. It is easily washed away in suspension by the waves, and having little tenacity, falls in slides and avalanches into the water, and is thus cut into deep, narrow gullies by rains. Its surface, in the District explored by me, is no more than two hundred and fifty feet above the Lake, sloping gradually from the mountains to the shore, as though it formed at one time the bed of an ancient sea. Beyond my District, however, on the waters of the St. Louis River on the west, and of the Ontonagon on the east, the red clay deposits reach to the height of four hundred and fifty to five hundred feet above the Lake.

Although it is called a *clay*, there is very little of it sufficiently argillaceous to make brick. On Madeline Island, and on the Maringouin Fork of Bad River, there are patches from which brick can be made, but in general it is too sandy, or too calcareous.

Specimen No. 46,* collected by me from the Maringouin Fork of Bad River, two

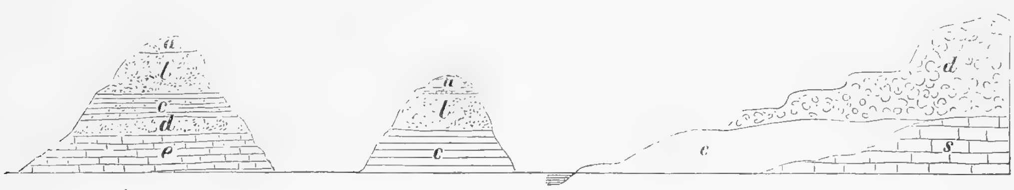
* Water of absorption,		5·5
Matter insoluble in hydrochloric acid, 59·0; of this, after fusion with carbonate of soda, 13·4 was soluble, leaving insoluble		
Pure silica,		46·6
Carbonic acid,		7·0
Sulphuric acid and chlorine,		a trace.
Soda,		2·6
Potash,		0·6
Alumina, soluble in hydrochloric acid before fusion with carbonate of soda,	7·0	
" " " " after " " "	10·5	
	——	17·5

miles above its junction with the main or Middle Fork, is a ductile clay, that becomes hard and tough at a moderate heat in a common fire. On the "Isle aux Barques," the lime was so abundant that it had formed in amorphous concretions throughout the mass. A very few leaves and decayed sticks have been seen in these red, marly clays, with carbonaceous matter and lignite; but such organic contents are not of usual occurrence.

Along the coast there are interstratified beds of sand and gravel of a local character. The section given by Mr. Randall, in the Report of 1847, and those I give below, illustrate this fact. In the interior, where the clay is visible in bold bluffs, along the water-courses, it is more uniform and less intercalated with coarse drift. It rests not only on the sedimentary unaltered rocks, but also on trap and metamorphic and igneous rocks, as may be seen by consulting Sections 1, 2, 3, 4, W.

The bold and curiously wrought face of the clay bluffs on the coast form scenes that attract the attention of the traveller, and are worthy the notice of the scenic painter.

The following sections of the quaternary deposits on the south shore of Lake Superior and the adjacent islands, will give an idea of their relative position and thickness. The first was measured at the north end of Oak Island; the second at the bluffs one mile west of Pointe Ecorse, or Black Point; and the third is a section of three miles, from the coast to the mountains, four miles southwest of La Pointe.



1 2 3

1. *a.* Coarse boulder drift, extending in the rear to the summit of the island, three hundred feet above the Lake. The slope of this exposure is 38°, its foot protected from the waves in some degree by the boulders that fall from the bank. *b.* Sand, thirty-five to forty feet. *c.* Red clay and boulders, twenty-five feet. *d.* Red and gray sand, twenty feet. *e.* Red clay and boulders, seventy-five feet. The total height above the Lake is one hundred and seventy-three feet. This section represents all the beds of this formation seen on the shore of Lake Superior.

2. *a.* Sand and clay, twenty feet. *b.* Gray sand, sixty feet. *c.* Red homogeneous clay, fifty feet. Total height above the Lake, one hundred and thirty feet.

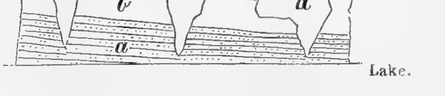
3. *d.* Coarse boulder drift, the top of which is four hundred and twenty-eight to five hundred and nine feet above the Lake. *c.* Red marly clay, ninety-five to one hundred and thirty feet above the Lake. *s.* Red and variegated sandstone, on which the red clay reposes.

This last section commences at the Lake near the mouth of a creek, which my half-breed voyageurs said was called by the Chippewas, Che-me-tau-gon-sibe; by the whites, Prairie River; and extends through the red clay to the top of the moun-

Protoxide and peroxide of iron, soluble in hydrochloric acid before fusion with carbonate of soda,	9·2	
" " " " after " " "	1·5	
		10·7
Lime, " " " before " " "	4·7	
" " " " after " " "	0·7	
		5·4
Magnesia, " " " before " " "	2·6	
" " " " after " " "	0·7	
		3·3
Loss, ...		·8
		100·0

tain, over which the winter trail to Fond du Lac passes. The terraces above the red clay are three in number, very abrupt, and well defined. I found the same number at about the same elevation at another section three miles north. The material of the drift is here almost entirely water-washed boulders, of the trappose, quartzose, granitic, and metamorphic rocks of Lake Superior, *very large*, and with little gravel and earth between them. The crests of the terraces have frequently the appearance of ledges, and one is every moment in expectation of finding some rock in place. I had much difficulty in coming to the conclusion that the boulder drift overlies the red clay, the junction is so much mixed and confused. The red clay, wherever the sand-rock is visible, rests on it without any intermediate coarse materials. The red clay never rises over about two hundred and fifty feet; seldom more than one hundred and fifty; while the boulder drift can be found four and five hundred feet and more above the Lake; it is therefore evident that the former was deposited in part, at least, before the violent action causing the coarse boulder-drift commenced. This action may have been contemporaneous with the latest stage of the clay deposit, extending over only part of the region, and operating at a higher level.

The base rocks on which the clay was deposited, rise as you recede from the Lake, so that this deposit becomes thinner away from the coast, although its surface rises also, but not so fast as the underlying rocks. Currents sufficiently powerful to transport boulders, two and three feet in diameter, to the tops of these hills, five hundred feet above the Lake, would of course commingle the two classes of deposits, and obliterate the exact line of division. The drift terraces continue southward from the section around the southern extremity of the mountain, so well marked as to be easily counted at the distance of ten miles, in clear weather. They are not of equal or of uniform height either way, from the section varying from twenty to fifty feet; the last bluff to the summit being from ninety to one hundred feet. Still, the impression is very strong on the mind of the beholder, that they are ancient beaches or shores; or if they are of submarine occurrence, that they have been modified by the temporary action of the waves of the retiring seas. They are very nearly horizontal, a circumstance distinguishing them from bars and ridges formed beneath the surface. I have nowhere else in this region seen well-defined terraces that are consecutive. The clay bluff of which a section is here given, is three miles west of Montreal River, and is sixty feet high.



a. Clay and sand, mixed. *b.* Light gray sand. *c.* Red ductile clay. *d, d, d.* The mouths of gullies.

The surface limits of this clay are indicated on the map. It is being reproduced at this time over the bottom of the west end of the Lake by the streams, which bring down large quantities after every rain, and by the waves, that dislodge and carry out from the shore the minuter portions in suspension. Some estimate may

be made of the rapidity of this sedimentary action from the case of the schooner Acorn, which was sunk off Cleveland, in Lake Erie, in sixty-eight feet of water, in the fall of 1843. She was two months in the water, and had upon her deck when raised *one-fourth of an inch* of mud. Lake Erie has about its western half a deposit of blue marly clay, upon which water acts rapidly; and here, as on Lake Superior, the water after storms is rendered turbid for several miles out.

b. Gravel and Boulder Drift.—The mass of the hills between Chegwomigon Bay and the Brulé River, is a recent drift. It is not very uniform in composition, but always marked by violent action of water. The central part of this peninsula presents large tracts of barren, water-washed land, and moderately coarse gravel. Both the western and eastern knobs and ridges are of coarse materials; and towards the point or extremity about the "Detour" and the adjacent islands, the sand and boulder matter is found, as represented in the sections, interstratified with red clay. Wherever we descend to the level of one hundred to two hundred and fifty feet above the Lake, the red clay is met with, extending from the shore along the valleys towards the interior, like bays indenting a coast. This drift formation is chiefly remarkable for its great elevation and its prodigious mass.

In the region in rear of the Penokie Range, it occupies a large tract, concealing the rocks to a great depth, rising eight hundred to one thousand feet above the lake-level.

The Sedimentary and Igneous Rocks.—The relative *age* of the rocks beneath the clay and drift is a subject upon which a prolonged discussion would be in place if theoretical considerations might be introduced here at large. The granites and syenites of the interior are no doubt the most ancient rocks of the District. After the protrusion of those extensive, interior granitic masses, many successive changes have occurred, but in what precise order is a question not easily determined. The immense sandstone deposits of the basin of Lake Superior must have been subsequent to the granites of Wisconsin, Chippewa, and Montreal Rivers, and probably rested on them. Since that era, a prolonged and intense internal igneous action has taken place, and the trap, hornblendic, and greenstone masses have been ejected, and also with them irregular protrusions of *recent* granite and syenite. The metamorphic slates have been elevated during these convulsions, and the sedimentary rocks thrust away to the northward, and tilted up at high angles.

The old granites and syenites have been rent, and fluid matter, such as quartz and hornblende, inserted in the fissures and between the beds. Along the northern portion of the Penokie Range an outburst has taken place, as it were between the sedimentary rocks and their ancient basis, on a line from the Montreal to Lac des Anglais; but the overflows have not been confined to one volcanic effort. The black and red trap, against which the conglomerate abuts, is doubtless due to a different effort from that which produced the greenstone trap-rocks, that rise between the East Fork of Bad River and the Montreal. The augitic, hornblendic, and syenitic mountains between the East Fork and the main stream, differ in form, in

chemical constitution, and bedding or stratification, from either the greenstone or black trap.

Proceeding along the mountain ridges of the northern part of the range, between the main stream and the outlet of Lac des Anglais, we encounter other varieties of rocks, felspathic, granitic, and hornblendic, in their composition, apparently an independent uplift or outburst. Along this whole line, however, the metamorphic rocks of the southern ridges of the range are continuous from near the Montreal to Lac des Anglais. They have, at different times, been pushed over the granites at the south; distorted, broken, and tilted up in different degrees, but always in the same direction. The northern portion of the range exhibits to my mind evidence of *four* periods of igneous action; producing *four* formations of rocks of a trappose cast, which I have represented separately on the map.

They are:—1st. Black and red trap; 2d. Greenstone trap, embracing or graduating into massive hornblende and syenite, at the west; 3d. Augite and hornblende rocks in mass, also embracing granite and syenite; 4th. Granite, syenite, and coarse hornblende rocks, north of Lac des Anglais.

But how to decide the *order*, or relative age of these protrusions? It appears that the same materials, under different circumstances of fluidity, pressure, and rapidity of cooling, may take all these forms.

At present I can only place these four varieties in *one group*, filling a geological epoch of no great duration, and place it between the era of the red sandstone deposits and the metamorphic uplifts; for it is by the appearance of this group that both those systems have been pushed aside, one to the north, the other to the south. Whether the schistose rocks, before their upheaval and metamorphosis, were older or newer than the sandstone, I do not decide; but both the schists and the unaltered sedimentary rocks are *more ancient* than the above group numbered from *one* to *four*.

The subdivision which Dr. Houghton and all subsequent geologists call the conglomerate, is apparently a *breccia*, resulting from mechanical disturbance of the sandstone by the intruding masses of trap. It probably took place before the overlying sandstone had become indurated, and the reason why the pebbles of trap that compose a large portion of the conglomerate rock are more rounded than is usual in breccias—having even a water-worn aspect—is the extreme agitation that took place. The thickness of the sand-rock is immense, and the passage of other rocks through this distance, always in contact with each other, would give the fragments a rounded form. The protruding granites of the great core of Plutonic rocks in the northern part of the State of New York, has left the Potsdam sandstone in many places in the form of a conglomerate, where the pebbles are granitic.

On the north shore, in the vicinity of quartz outbursts, through the altered sand-rocks, the crushed masses, next the quartz, have all degrees of roundness, from angular fragments to oblong spheres, according as the motion has been great or small.

At the Aminekan River the conglomerate extends but a short distance from the trap, wedging out in the course of a few rods, and replaced by the stratified sand-rock. It is never seen far away from the trap, and wherever the junction of the

trap and sandstone can be examined, it is almost sure to be present. There are cases where the trap, instead of being forced through the strata, across the stratification, has spread out between the beds, forming alternate strata of trap and sandstone, without any visible conglomerate. The view here taken seems to have been the theory of Dr. Houghton, who calls the conglomerate a "trap tuff," in his Report of 1841, in which Mr. Foster of the Michigan Survey concurs. I have noticed it merely to add my observations as confirmatory of the correctness of those views.

SECTION II.

PHYSICAL ASPECT OF THE BAD RIVER COUNTRY.

THE Montreal River, although it forms the boundary between Michigan and Wisconsin, from its mouth to the forks, is a stream small in size, and its sources are not more than forty miles from the Lake.

Above the Forks, its several branches collect the waters from the swamp region of the summit-levels between the Mississippi and the Lake basins. About ten miles west of the mouth of the Montreal, a much larger stream discharges itself through an extensive swamp or "*mashkeg*," on a low, sandy shore; which is called "*Mauvaise*" or "Bad River;" by the Chippewas "*Mashkeg-zibe*," or the "River of Marshes." In the interior it soon divides into branches, spreading right and left, parallel to the coast, and although it does not take its rise further inland than the Montreal, it drains a much greater field. The western, or Mashkeg Fork, discharges into the main stream at the "Mission," where there is an Indian village four miles from the Lake. Appearances indicate that there was an ancient channel, different from the present, which bore away to the left, or westward; about half a mile below the Mission, and entered Chegwomigon (pronounced Shag-*wau*-mi-gon) Bay. There is a bayou through the swamp at present, along this apparent channel, called the *Cau-cau-gon*, and boats and canoes, by making a portage of about eighty rods, frequently cross that way to La Pointe, when the weather is rough on the Lake.

The Mashkeg Fork heads at Long Lake, and has three principal branches,—Pike River, Rivière l'Eau Claire, and Rivière la Brache. The corresponding waters, on the other side, are the heads of the St. Croix; and the dividing ridge, by Dr. Norwood's barometrical measurements, is from six hundred and fifty-six to seven hundred and twenty-one feet above Lake Superior. The branch next in order as we ascend the Bad River is called the "East Fork," entering from the east about seven miles above the Falls, following the stream, or fifteen miles from the mouth in a direct line. By water, it is at least twenty-five miles to Woods's Farm at the Falls. The river is generally navigable for small Mackinaw boats, and is very sluggish till within six miles of Woods's. The bottom land is wide, thickly covered with sugar-trees and rushes, and the soil unsurpassed in richness. On these bottoms we saw continually deserted cabins, with small patches of potatoes around them, where such Indians as are not too lazy, and the half-breeds of La Pointe, come in the

months of March and April to make sugar. It is said that an industrious family will make from one thousand to fifteen hundred pounds, and that the trees produce from four to ten pounds each. Sugar is with the Chippewa an article of food; and the sugar-making season is hailed with joy, as putting a period to the starvation of winter. White men affirm that the trees would yield much more if the sap was carefully saved and gathered. The rushes furnish food all winter for Canadian and Indian ponies, and for such cattle as have been brought there. Mr. Woods, who has resided four years at the Falls, says his cattle winter well on rushes alone, which they pick out of the snow, sheltering themselves at night in the thick evergreen timber.

The bar at the mouth of this river is such that vessels cannot enter; but the mode of improvement adopted on Lakes Erie and Michigan would insure a good harbour.

About six miles above the Mission, or ten miles from the mouth, in low water, the shoals commence, and occasionally the current is strong. The red clay-banks are first seen about two miles above the Mission, where the river approaches the outside of its immediate valley; and they vary from forty to one hundred feet in height.

The "fall" consists of a series of leaps, of one to three feet each, over the tilted edges of red sand-rock. The descent, which is very straight, regular, and beautiful, is in all twenty-two feet; affording water for a large amount of machinery. In floods it rises eight to eleven feet below the Falls, but near the mouth the rise diminishes to five, four, and three feet, the waters spreading out through bayous and marsh meadows.

From Woods's it is necessary to make a portage of two miles, on the west side of the river, around the falls and the rapids above, rising, according to my barometer, forty-five feet. After this, we found no difficulty in ascending, with a birch canoe, by estimate, fourteen miles, to a raft on the next westerly fork, passing on our way the mouth of the East Fork, and the Middle Fork, or main stream.

The second branch from the west having, as I could learn, no name, I have called it the "Maringouin Fork" in my map, in commemoration of the myriads of musquitoes that inhabit its banks, that being the name the half-breed French give to those pests of the Bad River region. The Maringouin has its sources near Long Lake, on the west, and on the south interlocks with the upper branches of the Chippewa River, among some lakes, enclosed by drift ridges, which are, by barometrical measurement, eight hundred and seventy-one feet above Lake Superior. As there is but little rise from Woods's Falls to the raft, it is easy to perceive that the remainder of this fork must have numerous rapids, chutes, and falls.

Where the last-named branch leaves Bladder Lake, there is a wild cataract, through a gorge, where the water plunges over one hundred feet in one-fourth of a mile. Also, at the outlet of Lac des Anglais, the chutes commence at the very lake, and as it is about six hundred feet above the Maringouin Fork, and not more than seven miles distant, there must be a succession of chutes till it leaves the mountains.

About ten miles up, the "East Fork" tumbles down from the mountain range of

trap and conglomerate into the plain of red clay that occupies the space between the mountains and the Lake. As the lower part of all the branches of Bad River and the main trunk itself are washed out of the red clay deposit, the water has a thick chocolate-red colour when there are rains in any part of the region. The first falls, in ascending the East Fork, are over the conglomerate and sandstone rocks, where the river rushes through a gorge, with a descent of one hundred and five feet in about four hundred and fifty feet along the channel.

Forty rods above is a second series of chutes, plunging sixty-five feet in one-fourth of a mile over trap and conglomerate, the highest single cataract being twenty-eight feet.

A few miles above the upper chutes, the stream assumes a north-and-south direction through the mountains, and, spreading into numerous arms, gathers its supplies in the lakes, ponds, and marshes, adjacent to the heads of the Montreal.

Between the "Maringouin Fork" and the "East Fork," there are two principal tributaries of Bad River, in size a little less than the other three, but capable of furnishing, by their volume and their rapid descent, an unlimited amount of water-power.

The most easterly of the two middle forks I have called "Tyler's Fork," which is divided above its falls into two equal branches; the other, which preserves the general direction of the main trunk, may, with propriety, retain its name, as the Mashkeg or Bad River.

There is no canoe navigation on Tyler's Fork, or the Upper Bad River, so swift is the current and narrow and crooked are the channels.

Tyler's Fork comes out of the mountains about twelve miles southeast by south from Woods's, in a chasm, two hundred feet deep, in the red sand-rock and conglomerate. The junction of its ten branches takes place in this narrow gulf or "cañon," the eastern branch making a plunge of forty-two feet, succeeded, as you ascend, by a series of chutes over trap-rocks forty feet in one-fourth of a mile. Mr. D. Tyler, of the Charter Oak Company, made a location here, and built a rude cabin at the edge of the falls.

The westerly branch comes down this "cañon," occupying its whole breadth, between mural precipices of conglomerate and trap. The observer, standing at the crest of the lower fall, hears the roar of another, apparently not far distant, and, clambering over the rocks in that direction, comes suddenly upon a cataract, peculiar for its romantic figure, even when compared with those numerous waterfalls that astonish the traveller upon the waters flowing into Lake Superior.

The perpendicular fall is thirty feet, divided into different channels by the inequality of the trap-rock, which is alternately hard and soft, and across the whole, raised up and lodged by high floods many feet above the water, are large, naked pine trees, resting, like the stringers of a bridge, upon points of rock projecting from the shore. The descent from the foot of this fall to the other is thirty-seven feet in about sixty rods.

We discovered no remarkable falls upon the Upper Bad River, although they probably exist. Where it passes the Penokie Mountain, there is a continuous rush of its waters for a mile and a half, giving out the sound of a waterfall in the

distance. It passes near one of the bluffs of magnetic iron ore, to which reference is made elsewhere.

There is a continuous mountain chain from the Montreal River to Bladder Lake, the prolongation of the Porcupine Mountain Range in Michigan. I have called it the *Penokie* Range, this being the Indian word for iron, which is found in its westerly portion in great force.

This is no part of the Coast Range, that extends from the Porcupine Mountains to the mouth of the Montreal, composed, principally, of conglomerates and slates, but a more southern range, removed from six to eight miles back. The Penokie Range is visible, throughout its entire length, from La Pointe, or from the water twenty miles off shore, dropping down suddenly near Bladder Lake, on the west. Its outline is marked by notches and sharp-cut angles, closely resembling the trap ranges east of the Montreal, of which it is a prolongation. But a practised observer, passing the eye along the range to the east, beyond where the Montreal cuts through it, perceives that the trap-rocks of Black and Presqu'ile Rivers are more *isolated* and more *conical* than those of the waters of Bad River.

The summits overlooking the latter are equally numerous and confused, but more flat, with vertical faces, indicating volcanic action likewise, but in modified form. The general line of the range is southwest by west, which removes it more and more from the coast, as it is pursued westward.

The elevation is to the eye the same throughout, but the measurements made by barometer show that the eastern portion is slightly the highest. At the crossing of the Portage to Lac Flambeau, it is eleven hundred and eighty-two feet above the Lake; at what is apparently the highest peak, four miles west, twelve hundred and forty-two feet; at the crossing of the trail, sixteen miles southeast by south of Woods's, eleven hundred and eighty-six feet; and south of Lac des Anglais, eleven hundred and eighty-nine feet. The length of the range is about thirty-five miles; the breadth very variable; sometimes reaching eight miles.

Looking from the most elevated ridges towards the Lake, the country below has the appearance of a flat field, densely covered with evergreens; beyond which is the open Lake, the low Apostle Islands, originally parts of the same plain, not yet removed by the action of the waves, and far in the distance is the outline of corresponding mountains on the north shore. At the northwest, the bold drift-hills that lie between Chegwomigon Bay and the Brulé River, are seen projecting into the Lake at the Detour.

Behind the Penokie Range, looking south towards the interior, the adjacent lands are lower by two to three hundred feet, but the descent is sometimes very gradual and again more rapid, so that the horizon view, fifteen to twenty miles distant, representing the dividing ridge, is apparently on the same elevation as the Penokie Range. The easterly portion of this back country is more rolling and abrupt than the western. Where the waters of Bad River and Chippewa River interlock, is a vast tract, sloping gently to the north, full of tamerack and cedar swamps, and lakes and marshes, of little or no practical value, unless it be in future for its pines. These waters, which take their rise in the same swamps with the Wisconsin and Montreal Rivers, are in a region more elevated and rolling, with some ridges of good soil.

In this region we have a state of things in regard to soil, the reverse of what is usual in mountainous countries. The best soil is on the mountain ridges and slopes. The low grounds are generally swampy, and covered with thickets of tamerack, birch, white cedar, balsam, and spruce, and occasionally pine. At the foot of the mountain ranges, where the slope graduates into the low lands, there is an abundance of hemlock, and the ground is covered with moss, and a shrub called ground hemlock, to the continual annoyance of the traveller. Higher up the slopes, and on the summit, the prevailing timber is sugar maple, of a strong, heavy growth, a few yellow birch and pine trees interspersed. The sugar-tree soil is always good.

On the lake side of the range, the great plain is a peculiar tract, cut into steep gullies near the lake and near all water-courses, but remote from them, a flat, uniform surface, without stone or ridges, and, away from the swales and swamps, destitute of permanent water.

The timber is very close, though not high, and the soil appears to be good. It produces in the moist places native grass of good quality, and on the dry portions dwarf pine, aspen, balsam, and birch.

The mountain ranges are bountifully supplied with springs, rivulets, and creeks, of the coolest and purest water. Roads may be made with reasonable expense along the ranges; the climate cannot be surpassed for health; and, if the winter seasons are not *too long*, for they are not *too severe*, about one-third of the Bad River country may yet be occupied by men who till the soil. It is well settled, by observation, that the severity of winter is greater on the dividing ridge, forty and fifty miles south of the Lake, than it is between the range and the coast.

I shall refer to the climate more fully in another place.

SECTION III.

COUNTRY BETWEEN THE BAD RIVER AND THE BRULÉ.

From the western branches of the Mashkeg Fork of Bad River, to the waters of the Brulé, or Burnt Wood River, called by the aborigines Wisacodé, is a mass of upland drift, through which no rock has been seen in place, except in the beds of streams, or at the margin of the Lake.

About the sources of the streams, the country is elevated seven hundred feet above Lake Superior, and is more level and swampy, with, of course, more lakes and ponds than towards the edges of the promontory, at the Lake. As one proceeds from the head waters towards the mouths of these streams, the effect of their waters, in cutting down deep channels in the sand and gravel drift, is manifest in the sharper outlines of the hills, and in more frequent and abrupt valleys. In the central part of the tract under notice, the surface and the mass of the hills or mountains, are composed of soft materials, sand and light gravel; producing large white and yellow pines, and in places where sand predominates, large fields of huckleberries, growing among scattering cypress and dwarf pines, many miles in extent. On the summits of the ridges composed of coarser materials, such as large

gravel, loam, and boulders, the soil is better, producing sugar-tree, black oak, and white pine. The swamps produce tamerack or cedar.

These mountain ranges of drift maintain their elevation quite to the extremity of the point or promontory opposite Oak Island, where their slopes are so abrupt that the distant observer mistakes them for a trap range. But on examination, the red sand-rock is seen peeping out from the bases along the coast, and occasionally for a few miles up the channels of the water-courses. Above, there is nothing but masses of red clay and drift; the clay occupying the valleys and lower portions to a height of three hundred feet. These formations will be discussed in another place.

On the dry portions of the red clay, which is here, as usual, on Lake Superior, but little rolling, we find the aspen, birch, and white pine. On the sandy, huckleberry lands, where the pine is of moderate thickness, large districts have been overrun with fire, leaving a vast forest of blackened trunks, producing upon the mind a vivid impression of solitude and desolation.

Of course, such a soil is of no value to agriculture. The most favourable portions for tillage are on the waters of the Cranberry and Iron Rivers, after leaving the Lake a few miles. It is a universal rule, that the immediate coast of the Lake, and, in general, the deep gulfs through which some of the rivers and streams flow, produce a tangled forest of cedar, spruce, balsam, and birch, much more forbidding than it is a few miles back from the Lake. The moist atmosphere next the water, and the increased circulation and force of the winds, together constitute a *local climate*, which is favourable to those hardy evergreens, and to the birch. It may be said that between the summits of the mountain ranges and the level of the Lake, there are *three* climates, indicated by the changes in the growing timber. Where the soil is good, the highest portions produce sugar maple, black oak, and white pine. Towards the base of the most elevated ridges, hemlock begins to flourish, which graduates into cedar, balsam, and spruce, on the swampy portions adjacent. On the red clay plains, corresponding in level with the swampy portions, as I remarked in the description of the Bad River country, spruce, dwarf pines, balsam, aspen, and birch, spring up very thick, the result of a peculiar and tolerably good soil. This thick wood, extending over a large tract nearly on a level, serves to check the winds, and protect both animals and the soil, in some measure, from the severity of winter. But I do not instance this peculiarity as a climatic result. It belongs rather to the soil, and the physical characteristics of the flat clay region. The differences, that appear to me owing to different conditions of heat, moisture, and circulation of air, are characterized—1st, by the *predominance* of sugar-maple; 2d, by the *predominance* of hemlock; 3d, by the fringe of compact forest bordering the water, composed of white cedar, spruce, balsam, and birch. The birch may be seen at all elevations, and in the valleys of the richer uplands there are occasional instances of thrifty white elms.

The drift-hills* that divide the waters that flow into Chegwomigon Bay and the Mashkeg Fork from the waters of Iron or Penokie River, are in general barren and unfit for cultivation.

* For details of heights, see profiles and sections.

The Apostle Islands.—When the waters of Lake Superior assumed their present level, these islands were doubtless a part of the promontory, which I have described as occupying the space between Chegwomigon Bay and the Brulé River. They are composed of drift-hills and red clay, resting on sandstone, which is occasionally visible. In the lapse of ages, the winds, waves, and currents of the Lake cut away channels in these soft materials, and finally separated the lowest parts of the promontory into islands and island-rocks, now twenty-three in number, which are true outliers of the drift and sandstone. A new islet has been separated from the north-eastern point of Pug-a-tau-bau-minnis, or "Fishing-Line Island," since the surveys of Captain Bayfield, in 1824, '25, and '26.

I found, in passing among the islands, that no map in my possession gave even a good general idea of their size, form, and position. Afterwards, I had the good fortune to examine a copy of Bayfield's map, in the hands of Mr. Armatinger, a Canadian gentleman, which represents them truly, and from which I have taken the islands and adjacent coast.

I have since seen Farmer's Map of the Upper Peninsula of Michigan, and find the islands correctly copied from Bayfield. At a distance they appear like main land, with deep bays and points, gradually becoming more elevated to the westward. "Ile au Chène," or Oak Island, which is next the Detour, is a pile of detached drift, two hundred and fifty and three hundred feet high, and is the highest of the group. Madeline, or "Wau-ga-ba-me" Island, is the largest, being thirteen miles long, from northeast to southwest, and has an average of three miles in breadth. "Muk-quaw," or Bear Island, and Eshquagendeg, or Outer Islands, are about equal in size, being six miles long and two and a half wide.

They embrace, in all, an area of about four hundred square miles, of which one-half is water. The soil is in some places good, but the major part of it would be difficult to clear and to cultivate. The causes to which I referred as giving rise to thickets of evergreens along the coast of the Lake, operate here on all sides, and have covered almost the whole surface with cedar, birch, aspen, hemlock, and pine. There are, however, patches of sugar-tree land, and natural meadows. On six of them I did not discover the base rock, and conclude that they are composed of clay and drift to the water's edge.

On all the others, the sand-rock is visible in places on the coast, which I have denoted on the map, and which make a wild, bold, and dangerous shore. The rock is often worn into grottoes, detached pillars and blocks, caverns, arches, and niches, through which the waves resound on the slightest agitation of the water.

It is upon the northerly and easterly shores that the rocks show themselves most frequently; in no instances that I have seen, more than forty-five feet above the water. The southerly and westerly sides show red clay and drift, occupying much more than half the coast.

The waters around the islands afford excellent white fish, trout, and siscowet, which do not appear to diminish after many years of extensive fishing, for the Lower Lake markets. For trout and siscowet, which are caught with a line in deep water, the best ground of the neighbourhood is off Bark Point, or "Point Ecorsé" of the French. The estimate of this season was one thousand barrels for the La Pointe fishermen.

That portion of the soil of the islands fit for cultivation produces potatoes and all manner of garden vegetables and roots in great luxuriance. In the flat, wet parts, both the soil and the climate are favourable to grass; and the crop is certain and stout. Oats do well; on good soil I have no doubt that wheat would be a good and sure crop, if well cultivated.

I did not see any fruit that appeared to be in perfection, except currants and raspberries. Cherry trees and apple trees grow, but the fruit seems inferior in character to those grown farther south.

The above details, relating to the capacity of the islands for human subsistence, are presented more at length, because, I am told, a proposition has been or will be submitted to the Government, for colonizing them with Indians, whose territory was ceded in 1842, and who are soon to be removed.

In regard to health, no portion of this continent surpasses the Apostle Islands. In the summer months, they present to residents of the South the most cool and delightful resort that can be imagined; and, for invalids, especially such as are affected in the liver or lungs, the uniform bracing atmosphere of Lake Superior produces the most surprising and beneficial effects.

SECTION IV.

COPPER VEINS.

Within the District on which I am now reporting, I find no lands that I deem worthy of reservation as mineral lands, under the terms of the act of 1847. The iron-beds, which are fully noticed elsewhere, do not appear to come under the provision of the act. In the years 1846 and 1847, many locations were made for mining copper, upon lands west of the Montreal River. The judgment of many of the explorers engaged in making those locations, is entitled to great weight. They were good woodsmen, who fearlessly penetrated the most remote and forbidding parts of the country, and were close observers, traversing the region in all directions. To their acuteness, stimulated by the hope of speculation, to their energy and intelligence, and to the capital invested by those for whom they acted, the public owes the principal practical results that are now seen in the mining region of Lake Superior. But in 1845 and 1846, the system or law of the veins was not fully understood, for they were new, obscure, and complicated. The mines of other countries did not furnish a certain guide. There existed here in truth a different state of metallic diffusion, that may be termed the Lake Superior System, which was to be understood only after long study and examination. This examination was obstructed by many discouragements, such as those who have not been in the country can scarcely imagine, so that the labours of hundreds of explorers were necessary to the task of expounding the mineral veins of the country. In 1845, it was generally believed that the spar veins of the conglomerate were the most promising of any. In 1846, the *parallel* veins of the trap were not known, or if so, were not generally relied upon by explorers. The *perpendicular* or cross veins in the trap were then considered the only profitable sources of mineral.

More recently it has been ascertained that there were large masses of *unproductive* trap, while formerly a location made on the trap-range was considered good as a matter of course. When the discovery had progressed thus far, the Company was organized, stock issued and sold, and instalments called in, with the utmost confidence that veins existed wherever there was an outburst of trap.

If a small vein or fissure was seen, with or without metal, it was considered certain that a broad, rich, well-defined vein was near by. But at this day there are many small veins from which very good hand specimens may be procured, that lead to nothing valuable.

From the rich, productive uplifts of the Ontonagon River, as we proceed westward, copper does not seem to be as plentiful or as well concentrated.

All the works in the Porcupine Mountains are abandoned. Farther west, on the waters of the Presqu'ile and Black Rivers, which are next the Montreal, the mass of the trap-rocks has very much diminished; the ranges, instead of showing entire crests, appear in detached knobs, in which veins would be less likely to be regular or valuable. Where the range crosses the Montreal into Wisconsin, the uplifts are still short and detached, with feeble signs of epidotic veins. Specimens of red oxide and native copper have been seen near the river, not in place. Following the range westward, there is a gap where Mingopes (or Balsam) River passes through it in a chasm; here the rocks have changed from an imperfect amygdaloid to those of a hornblendic cast, containing much silex. Its texture is hard, close, and tough; its angles are sharp-cut and well-defined, apparently suffering nothing by the action of the elements. From thence you ascend what I call the greenstone portion of the range, where there are mural faces looking every way, forming a confused collection of precipices and gulfs, that compose the highest part of the range in Wisconsin. It is a labyrinth of dark valleys, with perpendicular sides, cliffs, and crests, two and three hundred feet above the adjacent low places. These elevations occupy a space two and four miles wide, and ten miles long. The mineral composition of these cliffs varies from an imperfect amygdaloid trap, with magnesian and chloritic amygdules, to an amygdaloidal greenstone, where the kernels are siliceous and epidotic. All these varieties may be seen in the space of a few rods, which are represented by specimens 67 to 77, and 80 to 84, of my collection.

On the north of this range, as represented on the map, is a belt of low black and red trap, lying between the greenstone and the conglomerate. It is less elevated than the range just described, by three hundred to five hundred feet, and comparatively level. Much of the trap is concealed by red clay and drift, but is seen occasionally in low ridges running parallel to the coast. On the south of the greenstone are hornblendic and clay slates, which rest against the granitic, syenitic, and quartzose rocks of the interior. Fragments of detached trap, containing native silver and copper, are reported to have been found on the range, but I have seen or heard of no *well-defined* veins.

The indications that have attracted most attention from explorers are in the black trap next the conglomerate, particularly at the Second Falls of the Montreal River, the Falls of the East Fork of Bad River, and the Falls of Tyler's Fork. In Cornwall, where veins pass from one rock to another, the miner expects a rich deposit near the

junction; but here it is found not to be a hopeful sign. The trap is not of a uniform structure, and is not soft and open in texture, but is close and tough. Theoretically, therefore, we should not anticipate well-defined and regular veins. The sections I have given, show that the trap-rocks are very changeable at all these points, which is a discouraging circumstance. Occasionally, a band of amygdaloid trap may be seen apparently as good as any on Point Keweenaw or the Ontanogon, which in a few steps is replaced by black flinty rock, approaching to hornstone. Veins and fissures passing from the amygdaloid to the flinty trap become compressed and crooked, are pinched and obstructed altogether, or degenerate into mere fractures or cracks. It is from this unpropitious irregularity, that seems to be everywhere prevalent, both in veins and the embedding rock, that I infer that for extended and profitable mining, the Bad River Range does not offer sufficient inducement.

After crossing the East Fork, the rocks answering to the greenstone become coarser in grain, more crystalline, and are augitic and hornblendic. The black trap belt, however, continues, and on its northern face contains particles of copper and of iron pyrites. In the augitic and hornblendic portions, there are, as represented on the map, patches of syenite and even granite, containing red felspar and epidote.*

This belt of black trap no doubt continues westerly, though not seen by us on account of the drift and red clay, as far as the portage to Long Lake, and probably protrudes into the drift, at intervals, to the Brulé and the Aminekan. Mr. Thomas B. Cumings, an active and close observer, saw it, in 1846, between the Maringouin Fork and the Middle and Main Fork. But neither Mr. Beesly nor myself found it in place, although there were signs of its being in the vicinity. Its breadth cannot be here very great, for the granitic, syenitic, and hornblendic rocks between Lac des Anglais and the Maringouin Fork occupy most of the space. The low uplifts seen west of Tyler's Fork, have the same or nearly the same bearing as those east of it, that is to say, northeast by east, northeast, and northeast by north. As they are situated on Long Lake and the Brulé, entirely out of the line of the eastern ranges prolonged, it follows that they are the terminations of parallel ranges less developed, their extremities only being seen. Probably there is an underground connexion with the trap rocks of the St. Croix, Kettle, and Snake Rivers. So far as I have examined, or could collect information, the prospect of regular and profitable veins along the whole line of the black trap uplifts, from the Montreal to the Aminekan, is no better than at the Montreal River, where a faithful trial was made and abandoned.

Copper doubtless exists in the quartz veins of the igneous rocks of the interior, but as yet seen only in scattering specks. The veins themselves are without system, and the rocks are almost everywhere inaccessible, on account of erratic deposits, so that no encouragement is offered for mining operations.†

The sections and their explanations will furnish an idea, in connexion with the foregoing remarks, of the details of the beds in which copper was supposed to exist in valuable quantities.

* See specimens No. 16 to 20, inclusive, of my collection.

† Specimens No. 95 and 96 of my collection contain carbonate of copper.

SECTION V.

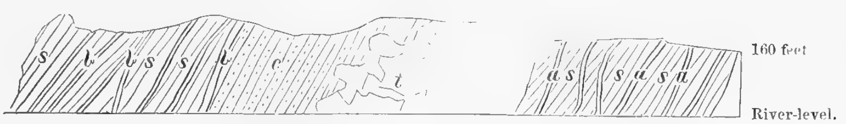
DETAILED SECTIONS.

Montreal River.—The best exposure of the contact of the trap and sedimentary rocks in the bed of the Montreal River, is on the Michigan side. Here, about three miles from the mouth, the "Cypress River Company" erected houses, and commenced operations for copper in 1846, and carefully measured the thickness of the slate and conglomerate beds. The latter is not uniform in thickness, owing to the disturbance of the invading trap. It measures eighteen hundred feet below the second leap of the falls at the Montreal trail. The channel of the river is sunk from one hundred and twenty to one hundred and eighty feet in the sand-rock, and is, for several miles from the mouth, very crooked. Its sides are steep, frequently perpendicular, and its width is often little more than its depth. The explorer can pass along it only in low water, by wading. The first fall is at the mouth of the river, fifty-six feet, in two cascades, over the tilted edges of the sand-rock.

The second fall is at the crossing of the Montreal trail, five or six miles by the tortuous channel, but not quite three miles by the trail.

The bearing of the strata here is not regular, but is about northeast by north, the dip northwest by west, 70°, 75°, 80° to 85°. The thickness of the black slate-beds, including shaly sandstone, is seven hundred and fifty feet, reckoning from the conglomerate to the clear sandstone. The sandstone which is seen between the beds, *b*, *b*, *b*, of black slate, has an apparent horizontal lamination, nearly at right angles to the dip of the slate-beds; but this is no doubt due to jointage, and not to stratification. Several hundred feet lower down the river than is shown in the section, is a band of well-defined conglomerate, one hundred feet thick, passing through the sandstone, with the same dip. At the junction of *c* and *t*, there is great confusion; protruding, mixed, and broken masses of trap, conglomerate, and sandstone, are seen, giving irresistible evidences of the former presence of mighty forces.

The section on the Montreal River, showing the junction of the sedimentary strata and trap, is shown in the following section.



1. 2.

SEC. 1.—*s*, *s*, *s*. Red sandstone. *b*, *b*, *b*. Bands of black slate, in sandstone. *c*. Conglomerate, eighteen hundred feet thick. *t*. Dark-coloured trap, with metallic veins.

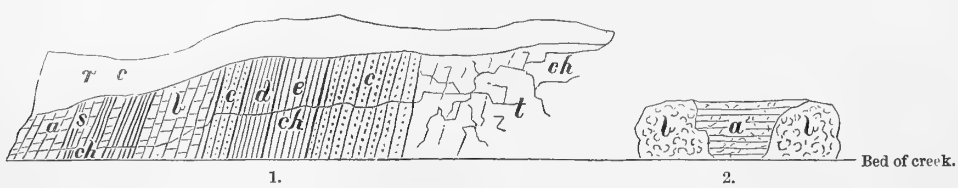
SEC. 2.—*a*, *a*, *a*. Hard, thin bands of sandstone. *s*, *s*, *s*. Soft, red, shaly sandstone.

The conglomerate is filled with veins and spots of calcareous spar; and the trap has many irregular, crooked, and limited fissures or veins, containing copper, spar, phrenite, quartz, and the usual materials of trap-veins. It was upon these indications that the Cypress River Mining Company made an energetic beginning, but has since abandoned the location.

The sketch of the right bank exhibits a singular case of bedding and lamination, nearly coincident, but varying a few degrees, as shown by the previous section (Fig. 2). *s*, *s*, *s*, represents the mass of the sandstone, in the state of a soft red shale, laminated, at an angle of about 75°; *a*, *a*, *a*, are thin beds of a hard sandstone, passing obliquely through *s*, *s*, *s*, at a higher angle. They are very regular and well defined, and may be seen about two miles, by the channel below the falls, at the crossing of the Montreal trail. As you approach the falls along the channel, the sandstone frequently assumes a brown or dark colour, and it and the conglomerate show the effects of alteration by heat. The two chutes of the upper falls, which are over trap-rocks, and very romantic, make a plunge, as measured by Mr. Ives, a government surveyor, of seventy-eight feet; and the river at the crossing, at the head of the falls, is by Dr. Norwood's measurement, three hundred and eighty-three feet above the Lake. It will thus be seen that the descent of the Montreal, in less than three miles by a direct line, is two hundred and forty-nine feet, exclusive of the cataracts. No description can convey an idea of the terrific force of this stream, swollen by heavy rains, as it rushes down the crooked and dark gulf which its own powers have excavated in the rocks.

About eight miles from the Lake, at the mouth of Raymond's Creek, and nearly in a south direction, are the abandoned works of the "New York and Michigan Mining Company," called "The Phelps's Location." Specimens 50, 51, and 52, of my collection, represent the character of the trap, as exposed in the East Fork of Bad River, half a mile above and below the cabins. It lies in alternate masses and beds of black, red, jointed, and compact trap, and of a tough amygdaloid. The only well-defined vein we saw about these rocks, was in the shaft, half a mile below the cabins, about one and a half inches wide, with a wall-rock of red trap, and the vein-stone siliceous without metal.

Descending the East Fork to the falls, over a rough bed, the trap-rocks are most of the way covered by drift. At the falls, there is a fine development of all the rocks known in the Montreal River section. The thickness of the conglomerate is not so great, for the reason that the elevating movement was not as extensive. The upheaval of the Montreal River chain was more bold and broad than that of the hornblendic rocks opposite these falls.



SEC. 1.—*r*, *c*. Red clay. *s*. Red sandstone, with thin bands of hard sandstone, *a*. *b*. Slaty and altered sandstone, three hundred feet thick. *c*, *c*. Conglomerate, twenty to one thousand feet thick. *d*. Altered shaly sandstone, or brown slate, forty feet thick. *e*. Altered shaly sandstone and conglomerate, sixty feet thick. *t*. Black, red, and amygdaloid trap. *ch*, *ch*, *ch*. Thread of stream, descent in cataracts, rapids, and chutes, one hundred and sixty-seven feet in half a mile.

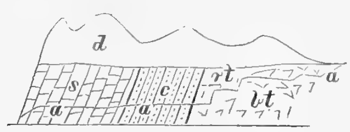
SEC. 2.—*a*. Thin-bedded sandstone, with few pebbles. *b*, *b*. Confused mass, all pebbles.

A location was made, embracing these falls, by Mr. Wood, of Bad River, and O. M. Hyde, Esq., of Detroit. The trap at the head of the cataracts is well displayed, resembling that of the Minnesota Mining Company, on the Ontonagon River. At

a chute of twenty-eight feet in height in the trap, there is a well-defined vein of laumonite and calcareous spar, bearing southeast by south, very thin and branching. I saw no copper in it, but the explorers who located it report a few particles. There is at the same place a cross course, ten feet wide, with good walls, the intermediate space filled with a broken, heterogeneous mass. The wall-rock is a soft, red amygdaloid, very loose, and jointed and bedded, without regularity; a majority of the joints run north 30° east and south 65° west. There are other laumonite veins, apparently barren and irregular, like seams; and also cross courses of unequal width and direction. The trap at the head of the chutes is not uniformly bedded, but the beds incline to the eastward more than to other directions. Pursuing the channel downward, through a narrow and tortuous bed, with vertical walls on each side, the conglomerate is met with, and at first presents an appearance of horizontal stratification, as represented in the preceding section, No. 2, in which the thin-bedded horizontal portion, *a*, has frequent lines of stratification, that pass directly through the pebbles. The adjacent mass, *b*, *b*, is composed almost wholly of pebbles of all sizes, crowded together in complete disorder. The horizontal lines of *a*, although apparently lines of lamination, are probably due to jointage, for in all other places the stratification is nearly at right angles to these lines, dipping north-northwest 85°.

We perceive, in the hard strips of the soft bed, *s*, a repetition of what was observed in the Montreal section. There is a similar bed of conglomerate, twenty feet thick, detached from the main bed. The altered and slaty beds, *d*, *e*, have their representatives in the Montreal section. Judging by external signs, the prospect for mining here is far less promising than at the Montreal.

The surface of the red clay is about two hundred and fifty feet above the Lake, showing a thickness here of more than one hundred feet. The sandstone is visible in the channel for one and a half miles below the last section, the dip remarkably uniform, north-northwest 82° to 87°, exhibiting some thin bands of conglomerate, very soft, and conformable to the general dip.



s. Red sandstone. *c.* Conglomerate. four hundred feet thick. *rt*, Red trap, two hundred feet thick. *bt.* Black, compact, and amygdaloid trap. *d.* Drift. *a*, *a*, *a.* Thread of stream,—chute forty-two feet, perpendicular.

Little need be said of the section here given. Mr. D. Tyler, for the "Charter Oak Mining Company," assisted by Mr. Erastus Heard, made a location on these falls. In the space of half a mile, the descent is eighty-four feet, to the foot of the last chute, which is perpendicular, and forty-two feet high.

At the head of this fall, is a crevice containing green earth, with a trace of the green carbonate.* There are other imperfectly developed fissures or seams in the bed of the stream, where the trap is visible, for nearly a mile above the falls, on the east branch. The fork here divides at the foot of the falls shown in the section. On the west branch, at seventy rods from the junction, is a corre-

* See Specimen 66 of my collection.

sponding fall, of thirty-two feet, over the trap-rocks. In ascending the gorge from the junction to the latter falls, we rise thirty-seven feet along a deep channel, in places thirty feet wide and seventy feet deep, its walls composed of a mixture of red breccia and red trap, in various states of hardness and of change. These falls present striking, rude, and picturesque views.

On the east branch, the trap-rock is very changeable, lying in apparent overflows, of limited thickness, where red trap, amygdaloid greenstone, and quartzose, gray, and compact black trap, are seen alternately, dipping at high angles southerly and easterly. Here, as in the two preceding sections, there appears to be no sufficient evidence of regular veins, and consequently of valuable mineral. The sandstone, *s*, is a repetition of the ordinary red and variegated sand-rock of Lake Superior, standing on edge, as at the mouth of Montreal River. The conglomerate bed, *c*, is conformable to *s*, or nearly so; its strike, south and by west; its dip west and by north 85°, 87°, and 90°; it graduates into the red trap-bed; so that it is not always easy to decide to which division the rock belongs. The conglomerate, as usual near the trap, has spots and seams of pure calcareous spar, extracted by the volcanic fires to which it has been subject. The slaty beds of sandstone near the conglomerate have disappeared; and not far west of this point, the trap itself is thought to be hidden under the red clay and drift.

The specimens of the collections on the South Shore of Lake Superior, Nos. 60 to 66, inclusive, represent the formations about the Falls of Tyler's Fork.

SECTION VI.

MAGNETIC-IRON BEDS OF THE PENOKIE RANGE.

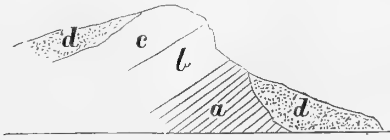
THE most easterly appearance of magnetic iron which I observed was in fissile black slate, about four miles west of the Montreal Trail, along which the Section No. 4, W, is made. The bed lies back of the trappose range, about sixteen miles from the Lake, in a protrusion of metamorphic slates, the argillaceous portions merely tinged with iron. About four miles along the strike of the beds, southwest by west, the bed was seen by Mr. Randall, in 1848, in the Fourth Principal Meridian in Township 44° north, eighteen miles from the Lake. From thence I and my assistant, Mr. Beesly, an active woodsman, and faithful and acute observer, traced it at moderate intervals, along the uplift, to the west end of "Lac des Anglais," or about fifteen miles, to where the range terminates.* Here the metamorphic slates, that first show themselves between the Montreal River and the Montreal Trail, on the east, sink beneath the level of the country, and are replaced by syenitic rocks.

By examining the Sections Nos. 1, 2, 3, and 4, W, attached to this Report, the position of the iron-bearing rocks will be found to be the same in each; and the details of the rocky beds above and below the iron are also the same, so that we

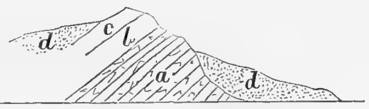
* There being but one surveyed line in the Bad River country, the distances are of course by approximate estimation.

may with confidence pronounce it to be a continuous bed from the meridian westward to Lac des Anglais. Its thickness, richness, and value vary very much; but we found it more or less developed whenever we crossed the range, and could get a view of the rock.

The geological relations of the iron-bearing strata are exhibited in the two following sections, the first taken near the trail that passes over the Pewabic Range, between the Forks of the Tyler branch of Bad River; the second, south of Lac des Anglais.



d, d. Drift.
c. Slaty magnetic iron, fifty feet.
b. Compact and slaty quartz.
a. Talcose slate.



d, d. Drift.
c. Iron-bed, twenty-five to sixty feet.
b. Quartz, thirty feet.
a. Hornblende and slaty quartz.

On the Pewabic Range, the strike of the beds is east by north; the dip north by west, 80° to 85°. The beds of quartz are of great thickness,—two hundred to two hundred and fifty feet. Near the junction of the quartz and talcose slate, the latter assumes the aspect of novaculite. The iron-bed is schistose in its structure, and is composed of magnetic oxide, sometimes alternating with beds of quartz. The total thickness of the talcose slate is not seen; it must be very thick, and is traversed by numerous veins of quartz. Its dip and strike are variable.

The bed of magnetic iron ore south of Lac des Anglais is of extraordinary thickness,—twenty-five to sixty feet. The dip here is northeasterly, and the layers variable in thickness that alternate with quartz, which latter repose upon hornblendic slate, running downwards into talcose slate. Here, as well as on the Pewabic Range, the dip and strike of the beds are variable.

The metamorphic strata are very much disturbed throughout this range; but agree in having the mural faces of the uplifts to the south and southeast, and the dip northerly and northwesterly at various angles of from 5° to 60°. The effect of this irregular action is to make detached ridges and crests, sometimes two, three, and five miles long, thrown up at different elevations and inclinations.

Sometimes the iron stratum is composed of laminæ of quartz and magnetic oxide, alternating, as at the crossing of the trail between the forks of the Tyler Branch of Bad River; also south of Lac des Anglais.

The proportion of iron and quartz is very variable, but the separation of them by mechanical means would in general not be difficult. The bands of ore vary from mere thin laminæ to a thickness of twelve and even eighteen inches, presenting sometimes a black surface, contrasting with the white and gray colour of the quartz, and sometimes a bright metallic gray colour. The thickness of the metalliferous portion varies in the extreme from five and ten feet up to fifty and seventy feet; and at the passage of the main portion of Bad River through the range reaches two hundred and fifty feet. These exposed faces frequently extend beneath the surface, where, of course, no estimate can be formed of their entire thickness.

There are many places in the mountain, west of Bad River, which present more

than fifty feet of quartz and iron, in about equal proportions. In the wild and deep ravines where the Bad River breaks through the range, there is a cliff of slaty ore, most of which comes out in thin, oblique prisms, with well-defined angles and straight edges, probably three hundred feet thick, including what is covered by the talus or fallen portions. I estimate more than one-half of this face to be ore; and, in places, the beds are from ten to twelve feet in thickness, with very little intermixture of quartz. There are portions of it not slaty, but thick-bedded. The dip of the laminæ is mostly north and by east, 80° and 85°. The convulsions that have occurred at this point have thrown a part of the range beyond the rest of it, to the northward, so that in crossing the river, and passing along the mountain to the eastward, for several miles, the ferruginous bed, as well as many of the associate strata, were not visible above the general surface of the ground. It should, however, be borne in mind, that the whole region is not only covered so thickly with timber that no distant views can be had without climbing trees, but the drift often conceals the rocks, over a large proportion even of the elevated ridges; in addition, the rocks themselves, previous to the era of the drift, have been the sport of giant forces, which tossed and tilted them about at various angles and elevations, realizing the fable of Atlas.

Where the west branch of Tyler's Fork crosses the chain, Mr. Beesly found the southerly face of the uplifts well charged with a rich, heavy ore, showing thirty, fifty, and seventy feet, with iron predominating over quartz.

All the specimens we saw were of the black magnetic oxide, without any of the red. The surface was not affected by weather, the angles of the rectangular slaty pieces and blocks that have fallen from the cliffs in great numbers, were entire, and not rounded by time. I infer that the mineral contains in its composition a notable proportion of silex.

The productive yield of such an ore can only be determined by trial in properly constructed furnaces, but judging of our specimens by weight, they will afford fifty to sixty per cent. of metal. The analysis of one specimen (No. 7) by Dr. Owen, yielded over sixty-six per cent.* For present use a supply of ore may be obtained from the rubbish at the foot of the uplifts, in blocks and pieces already

* The analysis of Specimen No. 7, from the slaty beds of the mountain, south of Lac des Anglais, gave as follows:

Peroxide,	51·5		
Protoxide,	27·1		
Mixed oxides of iron,		78·6	= 56·3 iron.
Silica,		20·8	
Magnesia,		00·6	
Alkali,		00·2	
Fluoric acid,		a trace.	
		100·2	

The excess arises from an absorption of oxygen by the protoxide. The analysis is subject to revision, if time permits, in this particular, but the result in pure iron cannot be materially changed. This specimen is apparently 10 or 20 per cent. below the richest pieces brought from the Range, and is above some of the poorer slaty specimens.

detached from the cliff and the accompanying quartz. Where it is not dislodged, it will be necessary to break the whole, and then assort it. There are cases where numerous particles of the oxides, both red and black (the protoxide and the peroxide), are disseminated through the quartz-rock above and below the regular beds. This might be separated by bruising and stamping,—a process which the whole must undergo, in order to be profitably wrought in the forges.

There is no limestone yet known in the region to be used as a flux; but there is an abundance of timber and water-power. There are certain proportions of iron and silex, and of silex and magnesia, that are easily fused. If the silex of this ore is not so excessive as to make it refractory, or if in practice that difficulty can be remedied by the use of magnesian slates, which are abundant, these mines may be wrought hereafter at a profit, and rival the works of Northern Europe.

The magnetic ores of the northern part of the State of New York, that have produced iron famous for its strength, are also siliceous. The magnetic iron ore is freed of a portion of its silex, at little expense, after being bruised, by the application of magnets acting on a large scale upon the magnetic particles. The part which enters chemically into the ore forming a silicate, is not wholly cleared by working, but gives a very fine-grained metal, that is peculiarly good for steel.

The famous Swedish iron is from beds of magnetic ore embraced in hornblende rocks, doubtless metamorphic, and analogous to the Bad River rocks.

The extensive mines or rather mountains of iron ore in Michigan, described by Houghton, Burt, Jackson, Foster, and Whitney, are also magnetic, and associated with metamorphic slates. These ores are, in some cases, more inclined to the peroxide than the Bad River beds; but specimens from the two regions are often so similar that no one would be able to separate them by the texture, colour, or weight. The geological associations are precisely alike. In Michigan, as in Wisconsin, the mountains composed of tilted magnesian, hornblende, and siliceous slates, enclose beds of ore. There, as here, on each side of the metamorphic range, are igneous rocks, of various ages and composition, quartzose, granitic, syenitic, and trappous. The ores of that region have attracted attention, and one establishment for making blooms direct from the ore, has been in operation more than a year. The iron is remarkable for its solidity and toughness, keeping its place better than Swedish, and no more brittle. It possesses the quality of being worked into fine cold-drawn wire, and has been sought after by an establishment for manufacturing wire in Massachusetts. The blooms brought from Lake Superior to the Pittsburg market are, however, represented as being inclined to "red short," that is, liable to crack under the roller or hammer, at about a red heat.

The position of the best exposures of ore which I saw is such as to require from eighteen to twenty-eight miles of transportation to reach the Lake. The nearest natural harbour is in Chegwomigon Bay, about twenty-five miles from the central part of the Penokie Range. At Montreal River, which is the nearest part of the coast, and from its mouth to the mouth of Bad River, there is no place where an artificial harbour can be made. At Bad River, there will be a good harbour when the sand-bar at the mouth is removed and kept clear by the construction of piers.

SECTION VII.

THE "IRON RIDGE" AND ORE-BEDS OF DODGE COUNTY, WISCONSIN.

During the last three years, these deposits have attracted much notice, partly on account of the interesting and anomalous character of the ore, and partly because of the great practical value of a bed thus situated. The "Wisconsin Iron Company" has the credit of making the first experiment upon this ore, and in fact, of erecting the first, and at present the only stack furnace in Wisconsin, so far as my inquiries extend. The same enterprising gentlemen, who were the pioneers in iron manufacture in the State of Indiana, where they erected the "Mishawaukie Furnace," upon the bog ores near the Michigan line, have directed their skill, capital, and energy to the same interest in the State of Wisconsin. Their works at Maysville, in Dodge County, are driven by water, and consume the ore of the "Iron Ridge," which is hauled on sleds, in winter, about four and a half miles.

The geological position of this ore is not determined with precision. Mr. Lapham, of Milwaukie, has traced the formations to the eastward of the boundaries of Dr. Owen's survey of 1839, in places, as far as Lake Michigan; but the fossils are so few, and so much of the surface of the country mantled by deposits of drift, concealing the rocks, and the limestones possessing lithological or external characters so little marked, and so little diverse at distant points, and their stratification so poorly defined, that it is very difficult to form a good opinion of the order of the strata.

There is great embarrassment in deciding upon the exact dip of such rocks, without a protracted examination. According to Mr. Lapham, the lower sandstone (F. 1) extends into Dodge County, at the northwest corner, and at the southwest corner; and the "Lower Magnesian Limestone," or F. 2, is seen through the western part of the county, resting upon F. 1.

In the southwest part of the county, along the range line, between Ranges thirteen and fourteen east, the "Blue Limestone," or F. 3, A, is clearly developed. After passing an interval of four and five miles to the eastward of the latter formation, in which the rocks are not visible, the "Upper Magnesian" or "Lead-bearing Limestone" F. 3, B, is visible, having a breadth of about six miles; the eastern observed limit being six miles to the west of Rock River, on the south line of the county. These rocks all dip easterly; the amount and precise direction not yet determined, nor yet the thickness of the separate formations.

Passing now over to the lake-shore, near Milwaukie, Mr. Lapham finds the succession of rocks, taken in the reverse order, as follows:

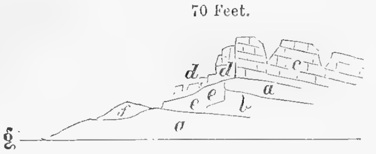
1. The "Corniferous Limestone" of New York and Michigan; corresponding to the "shell beds" of the cliff limestone.
2. The "geodiferous" lime-rock of Eaton, and Niagara Limestone, of the New York Reports, supposed to correspond with the lower part of the "Cliff Limestone" of Ohio, and F. 6 of Pennsylvania.

3. Next beneath the geodiferous, is a heavy bed of limestone, which Mr. Lapham calls, as a temporary name, the "Waukeshaw Limestone."

The Waukeshaw Limestone, like the geodiferous and the corniferous, which overlie it, dips to the east. It appears in the southeast part of Dodge County, leaving an undetermined space between its western outcrop and the eastern presentation of the upper magnesian or lead-bearing lime-rock, of about two townships, or twelve miles. It is in this interval, but doubtless in the same formation, that the iron ore occurs. It appears in the face of a bluff, looking westward, and running nearly north and south, parallel with that portion of Rock River between Horicon and Hustisville, and about four miles east of the river.

It exists on the surface in small, *flattened, oblong grains*, like flaxseed, but only about half as large, with a bright, brownish-red colour, inclining in streaks to black or bluish black; has an unctuous, greasy, magnesian feel; soils the fingers and clothes badly, and gives a light blood-red tinge to water flowing through it, when newly dug. Farther down in the mass, where it has not been disturbed by diluvial forces, it is darker in colour, more compact, distinctly stratified, and occasionally stony.

The following section of the "Iron Ridge" was taken at Mr. Theodore B. Sterling's steam saw-mill, Section 13, T. 11, north range, 16° east of 4th Principal Meridian, the course being east and west.



c. Bluff of cavernous limestone, from which springs issue. *a, a.* Hidden from view. *b.* Exposed stratified ore. *e, e.* Excavation. *d, d.* Large blocks of limestone. *f.* Material removed. *g.* Coarse drift.

The base of this section is the spring, at the spring-house, a few rods east of Mr. Sterling's dwelling-house, which Mr. S. estimates at thirty feet above the surface of the dam at Hustisville, which is two hundred and ninety-five feet above Lake Michigan. The elevation of the spring above the river is probably greater than is here given.

An excavation, *e, e,* has been made through the rubbish of the bluff to the ore in place, where a face of fifteen and a half feet is exposed.

It was not practicable by inspection to determine the limit of the ore below the bottom of the cut *e, e,* although an iron bar had been thrust down four or five feet, without reaching any other deposit. On the upper face, judging from the shattered and tumbling state of the overlying lime-rock, there should be from five to eight feet of ore, or some soft stratum, above the exposed portion. If this conjecture is true, there is at least twenty-five feet of the ore in place. Passing along the bluff to the southward, it inclines to the east, and shows red ochre for more than half a mile, in some places on the same level, at others higher up the hill, especially where it takes a more regular slope, and the cliff is not seen. From the crest of the bluff, at the section, the level descends to the eastward, and ochre covers the

lime-rock like soil or diluvium. To the northward, the same appearances are observed, and at about three-quarters of a mile, where the Wisconsin Iron Company take out their ore, the hill appears to be all ore for sixty feet in height. The surface ore is here mined almost as readily as sand or loose earth, only stripping the soil and taking out the roots that are intermingled with it. But the upper and external parts of the bed have evidently undergone movements, apparently some great diluvial force, from the westward, pushing the outcropping mass up the hill, wherever its face was not too bold.

This impression is given by the lines of deposition, which are not horizontal, but inclined and curved, following the form of the hill up and down along its western slope. There are also lumps of clay or marl, resembling the tough marls associated with the Cincinnati Blue Limestone, interspersed through the ore. As the excavations become deeper, the loose portions will doubtless change to a more compact and stratified mass, lower down the hill, like that seen at Sterling's Spring. I am told the same ore is found at intervals along the bluff, but sinking towards the base, along the heads of the Rubicon, southeasterly, to Hartford, a distance of about twelve miles.

The overlying limestone at Sterling's is a granular, gray, variegated whitish and yellow limestone, that makes good white lime. I neither discovered or could learn of any fossils in the lime-rock or the ore. The bluff extends northerly and westerly; and, at one and a half miles towards the furnace, presents a bold face of thick-bedded limestone of one hundred feet perpendicular, the apparent dip to the northeast, its base lower than the ore-bed, but no external signs of ore. The rock, however, contains iron, which causes it to turn from yellow to red, when it is heated in kilns.

The same bluff may be traced northerly towards Fond du Lac, trending to the northeast along the east shore of Lake Winnebago, in mural faces, and extending, with little interruptions, parallel with Fox River, and along the eastern shore of Green Bay to Sturgeon Bay. At the ore-bed, there are indications of an underlying stratum of marl or calcareous shale, which may on examination prove to be a member of the blue limestone. There is also in the bluff two miles north of Tayhedah, a soft stratum of a siliceous character, the fossils of which are very imperfect, but one is a *Pterinea*. These indications, when taken in connexion with the vicinity of the blue or Trenton limestone, a few miles to the southwest of the bed, point us to the "Clinton Group" of New York, or No. 5 of Pennsylvania, both of them iron-bearing formations, as the geological equivalent of these Wisconsin iron-beds.

In New York, the strata of ore in this group are two, one below and one above the Pentamerus Limestone; the lower one extending about twenty miles, as seen in the County of Wayne, its greatest thickness about two feet, and highly fossiliferous. It is called an "oolitic" ore, with a greasy feel, by Mr. Hall, and a lenticular or lens-shapen ore, by Professor Eaton.

In Pennsylvania, there is in the same formation a deposit, from six inches to twenty-four inches thick; its outcrop extending, with intervals, from the Juniata River, southerly, through Pennsylvania and Maryland, into Virginia, composed of

peroxide and carbonate of iron, with 15 per cent. of siliceous and argillaceous matter.

The analysis* of the Sterling ore, as given by Professor J. L. Cassels, of the Medical College at Cleveland, Ohio, indicates over 53 per cent. of iron.

Of the extent of this deposit, with so little excavation, and but a hasty examination of the region, in unfavourable weather, I can say little. It is already exposed in sufficient quantities to make it a certain supply for a long time; and theoretically it should occupy extensive tracts, where it is not visible, to the south and east. It probably exists in a wedge-shaped mass, between the rocks with irregular faces, giving it somewhat the character of nests, connected by thinner portions of the ore, the whole tapering towards an edge as it enters the hill. I find no examples of an ore having this internal structure, unless some of the ores described as *oolitic*, are intended to include other than *rounded* grains. Professor Cassels has seen iron ore in Scotland, having the same structure as Dodge County ore, and the same greasy, adhesive touch.

The Wisconsin Iron Company, under the management of John Niles, Esq., use the ore without burning, and find it to melt very easy without flux; in fact, it has been found necessary to introduce silex, in the shape of water-washed sand, to retard the process of melting, and thus improve the quality of the metal. In November, 1849, their charge consisted of fifty-five pounds of bog ore, sixty-six pounds of sand, thirty-five pounds of limestone, and six hundred and sixty pounds of the ochery ore, unburnt. The yield, with a moderately hot blast, was 35 to 42 per cent. of iron, the furnace running out three and a half to four tons of metal per day, of twenty-four hours, with a consumption of one hundred and forty-five to one hundred and fifty-five bushels of charcoal per ton. The castings were very smooth, and the sound and texture of the metal was good, but seemed to be less tough than other castings. The manager was about to try the effect of cold blast on the quality of the iron. I cannot learn that it has been wrought into bars.

* Peroxide of iron,	76·74	{ 53·72 iron. 23·02 oxygen.
Sesquioxide of manganese,	1·05	
Clay,	4·00	
Silex,	10·00	
Water,	6·00	
Loss,	2.21	
	100·00	

CHAPTER II.

DESCRIPTION OF THE COUNTRY BETWEEN THE WISCONSIN AND MENOMONIE RIVERS.

I DEVOTED the month of October to a reconnoissance of the rocks between these rivers; but only a small portion of so large a field could be personally examined by our party in so short a time. The Michigan survey had been partially brought up to the state line on the Menomonie, by Houghton, Foster, and Burt. The surveys in Wisconsin, of 1839 and 1847, had progressed easterly so far as the meridian of Fort Winnebago, leaving a space of unexplored territory which it was interesting to examine. Increase A. Lapham, Esq., an engineer and geologist of Milwaukie, who has for many years attentively examined the geology of the southeastern part of Wisconsin, liberally contributed his observations to me, and they are, so far as I know, the only authority on the rocks south of Lake Winnebago, and east of Rock River. With the limited examinations made by myself, the observations of Mr. Lapham were of the highest value in elucidating, by means of the rocks on the south, those I was studying on the north. I take this opportunity to express my obligations to him, and to state that his examinations, made entirely on private account, are extensive and correct.

My route was from Sheboygan to Fond du Lac (of Lake Winnebago), thence by Oshkosh, and down the Fox River (or Neenah) to Green Bay. Here I was joined by Dr. S. E. Beach, of Appleton, as an assistant, who proved himself a good observer and woodsman, and a valuable acquisition to the expedition. From Green Bay we passed along its western shore to the mouth of the Oconto, and up the same to its sources. Returning, we made a portage to Lake Shawano, ascended Wolf River to the falls, and thence descending Wolf and Fox Rivers, reached Oshkosh on the 1st of November.

On this route of the Oconto and Wolf Rivers, we saw no mountains; only a few low, rocky bluffs, and some gentle drift-hills, knobs, and terraces. The surveyors say that the country, from Lake Shawano to Green Bay, presents no hills, but only gradual swells, and a rich soil, inclined to be wet. The Indians, who furnished us maps of the portages, laid down some mountains north and east of Lake Shawano, but from the highest points we saw, being from one hundred and fifty to two hun-

dred and fifty feet above the streams, we discovered no land apparently higher. The red clay, as I have before stated, covers the rocks; and this, with the universal drift, effectually conceals them from view in the lower portion of the country.

The limestones, when visible, show but indistinct lines of stratification, and therefore their dip and thickness could not be measured, or even well estimated. Their fossils are not abundant or perfect; wherefore little can be done at present towards classifying them in detail. At only three points did we perceive the junction of the quartzose sandstone with the calcareous sand-rock that rests upon it. The sand-rock was nowhere seen in contact with the igneous rocks of the interior, but the outline or boundary of those rocks is very manifest in giving a peculiar contour to the overlying drift.

On the map, I have shown by deeper colours the places where the rocks are visible, and in fainter dashes of the same colours, given my conjecture of the limits of the formations between the points where they are seen.

An important object in the examination of the granites, syenites, and metamorphic rocks of the interior, was a hope that they might here, as in the Dead River of Michigan and on the Bad River of Wisconsin, contain important beds of iron ore. Although, as far as we went, the formations closely resembled the Dead and Bad River regions, we saw no beds or veins of ore; but from the extent of resemblance, should anticipate the presence of iron further towards the interior, than our route. A portion of this region has been surveyed into townships by Mr. Ellis, of Green Bay, and Mr. Conkey, of Grand Chute, and some of it subdivided into sections. Mr. Ellis closely observed the rocks over which he passed, took specimens, and made memoranda; and these, for Ranges 20 and 21, Townships 34 to 48, on the Menomonie River, are valuable contributions in disclosing the geology of the country. He found here granite, syenite, and hornblende rocks. These gentlemen, in their surveys, report no beds of iron; and their returns of the variation of the needle (a sure index of the presence of the magnetic oxides), as given me by the Surveyor-General, show but two or three cases of irregularities; and these may be charged to trappose rocks, into which iron enters as a constituent. On the low grounds about Green Bay, and on other low lands, and about springs, near the rivers that flow into the Bay from the west, are patches of bog ore; but these alluvial deposits are so irregular in extent, depth, quality, and richness, that they are an uncertain reliance, and to be confided in only after a faithful examination, by means of pits sunk in various parts of each bed. The metal produced from such ores is easily wrought, and of a good quality.

Sedimentary Rocks in the Eastern Part of Wisconsin.—The only formation east of the Wisconsin and Rock Rivers, that can be regarded as fixed beyond doubt in geological position, is a limestone, the equivalent of the "Trenton" of New York, and the Blue Limestone of Cincinnati. Neither the rocks above or below the Blue Limestone have been studied sufficiently to subdivide them into formations; nor has the extent of country occupied by each on the waters of Green Bay and Lake Michigan, been exactly determined. The difficulty of getting a sight of the rocks, owing to the accumulation of drift, and the scarcity of fossils, where they are visible, sufficiently explains why a classification cannot as yet be made.

I now proceed to give the facts I have gathered by observation and inquiry upon this subject, taking the Blue Limestone of Cincinnati as the geological horizon for comparison. Mr. Lapham has observed rocks of this age in the valley of Rock River, a few miles north of Lake Koshkonong, in Range 13 east, Township 6 north, Jefferson County, and again in Dodge County, in the same range in the east part of Township 10 north, they crop out to the westward, occupying a belt of about a mile in width, and consequently the thickness cannot be great. The same formation is seen on the eastern shore of Green Bay, at Little Sturgeon Bay, Township 27 north, Range 14 east, at the level of Lake Michigan. Between these points, about one hundred and twenty miles apart, I am not aware that it has been traced, or even seen, unless some of the *bluish-green* beds of limestone, about Lake Winnebago, and on Fox River, that I shall soon notice, are the equivalents of this formation. Dr. Houghton examined and laid down the same rock on the west and north shore of Green Bay, around the head of Little "Bay de Noquet" (pronounced Ba-de-nok), in Michigan.

The three points which I have noticed where this limestone makes its appearance, are nearly in a right line, which bears about northeast by north. The surface of the country on this line, from Jefferson County, rises to the east and northeast; but to the left or westward of it, around Lake Winnebago, and in the valley of the Fox River, there is a depression, along which the outcrop of the blue limestone may well be expected, curving to the northwest of the direct line between the present known points of outcrop.

I have selected the Blue Limestone as a starting-point from which to reckon each way up and down the series, because in Eastern Wisconsin it is the bed about which all geologists will best agree as to its position.

To show more forcibly the difficulties that exist in the present state of our examinations, in arranging these rocks, I will give the results of examinations made in the Silurian strata, both on the east, in Michigan and in Canada, and on the west, in Wisconsin. It should likewise be remembered, that neither the Michigan nor the Eastern Wisconsin surveys are complete or fully reported upon, and therefore the lights that are derived collaterally from these sources are not only not full, but subject to future modifications.

The New York system of rocks has now been traced from Virginia through Pennsylvania, and through New York, Canada, Michigan, Wisconsin, and Minnesota, leaving its vast area indeterminate on the west and northwest. We are therefore considering a portion midway between its extremes. A comparison of sections showing the order and nature of these beds, at different points, both east and west, and also of the region under consideration, may be useful and interesting.

A glance at the tabular arrangement, on the next page, of the rocks, as different observers have reported them, shows that although other beds change or disappear, the equivalent Blue Limestone of Cincinnati runs from the eastern part of Michigan to the western part of Wisconsin. Doubtless there are some imperfections in the grouping of the various formations by different authors, but a striking uniformity pervades the sections when we regard the broad space which they represent.

CANADA SURVEY. MESSRS. LOGAN AND MURRAY. Section from Gros Cap Range to Manitou Islands.	MICHIGAN SURVEY. DR. HOUGHTON. From Lake Huron along St. Mary's River to Gros Cap Range.	MICHIGAN SURVEY. S. W. HIGGINS. From Mackinaw to Grand Island.	MICHIGAN SURVEY. DR. HOUGHTON. Bay de Noquet to Chocolate River.	C. WHITTLESEY. Heads of Oconto River to Little Sturgeon Bay.	I. A. LAPHAM. Milwaukie to Madison, Wisconsin.	WISCONSIN SURVEY. D. D. OWEN. Falls St. Anthony to Keokuk.
1. Igneous rocks, Gros Cap range.	1. Trappose and igneous rocks. Gros-Cap.	1. Igneous and trappose rocks beneath Lake Superior.	1. Igneous rocks.	1. Syenite, granite, and metamorphic rocks.	1. Igneous rocks of Wisconsin River.	1. Igneous and trappose rocks of St. Croix, Rum River, and Mississippi.
2. Altered sandstones and conglomerates (Potsdam).	2. Red and variegated sandstones (Potsdam).	2. Red and variegated sandstones, base of Grand Island and Pictured Rocks.	2. Red and variegated sandstone (Potsdam).	2. Soft saccharoid sandstone, with breccia and red bands.	2. White and gray sandstone (F. 1), Madison, Wisconsin.	2. Light-coloured sandstone, Mississippi and Wisconsin (F. 1).
3. Trenton.	3. Cincinnati blue limestones and shales.	3. Upper gray sand-rock.	3. Calciferous sand-rock.	3. Siliceous lime-rock.	3. Lower magnesian limestone (F. 2).	3. Lower magnesian limestone, Mississippi and Wisconsin Rivers (F. 2), embracing red and white sandstones.
4. Utica slates.	4. Utica slate.	4. Trenton and Birdseye.	4. Birdseye and Trenton.	4. Bluish-green limestone.	4. Cincinnati blue limestone (F.3,A), Ripley Lake.	4. Cincinnati blue limestone (F.3,A), Falls St. Anthony and mouth of Wisconsin River.
5. Lorraine shales.	5. Medina sandstone.	5. Cincinnati blue limestone.	5. Cincinnati blue limestone.	5. Cincinnati blue limestone.	5. Upper magnesian limestone, lead-bearing lime-rock, Fort Atkinson.	5. Upper magnesian limestone (F. 3), lead-bearing rock. Dubuque, Galena.
6. Limestone of Drummond and Manitoulin Islands, disturbed by intrusive quartz, and other igneous rocks.	6. Limestone of Mackinaw and Drummond Islands.	6. Intermediate lime-rocks.	6. Intermediate lime-rocks.		6. Supposed red sandstone.	6. Devonian rocks.
		7. Mackinaw limestone.	7. Mackinaw lime-rock.		7. Waukeshaw limestone.	7. Coal-measures, Keokuk.
					8. Geodiferous or Niagara.	
					9. Shaly sandstone.	
					10. Corniferous, Lake Michigan, Milwaukie.	

Mr. Logan does not give the Blue Limestone, but has what is regarded as its equivalent, the "Trenton Limestone" of New York. The early Michigan geologists separated the Trenton from the Blue, probably as a provisional arrangement, based on lithological difference.

Let us now bring the comparison to bear on the arrangement of the rocks on the waters of Green Bay. Although I was unable at any point to get measurements for dip, it is evident that the rocks, as a system, plunge away from the great central uplift of igneous rocks, that is, to the east and south. Along the Neenah River, the dip is slight and irregular, the bedding of the rocks, although frequently well defined, is not traceable in long lines from point to point.

The general plunge being easterly and southeasterly, we are satisfied, as we progress from the shore of Lake Michigan westward and northwestward, that the rocks that appear to our view are older than those on the Lake. But in the absence of calculations on the dip of these rocks, their thickness cannot be measured, or even estimated with an approach to accuracy.

The limestone bluffs north and east of Tayhedah, overlooking Lake Winnebago from the southeast, appeared to me the highest rocks of the Fox River Valley, both

in a geological and physical sense. Here is a mural face stretching several miles each way along the shore of the Lake.

One mile east of Tayhedah, by a rough measurement, I found the foot of the perpendicular bluff to be one hundred and ten feet above Lake Winnebago, and its upper crest one-hundred and forty-five feet, in the order represented in the annexed section, taken one mile east of Tayhedah.

	Feet.
1. Yellowish-gray limestone, ...	16
2. Light gray limestone, ...	15
3. Talus and slope, ...	110
Total height of bluff, ...	141
Level of Lake Winnebago above Lake Michigan, . .	160 to 164

Beneath the bottom of the cliff, the rocks are not seen in place, being covered by fragments, fallen from above, and by the red clay. The slope, from the clay up to the cliff, is a mass of loose, jointed, cherty lime-rock, probably not very thick, covering some softer beds of the same, only slightly visible, in a fragmentary state. Above this is a compact, thick, coarse-bedded, light-gray lime-rock, 2, fifteen feet thick. Next above this is a compact, coarse-bedded, yellowish-gray limestone, to the general level of the country, sixteen feet. It is slightly fetid when broken, has reddish spots, and thin, crooked cracks or seams, filled with a dry, ochery substance. In the uppermost bed, there are small white siliceous spots, that stand out on the weathered surfaces, which, on examination, prove to be fossils, tolerably well preserved, apparently an *Atrypa,** and a coral like the *Catenipora agglomerata* (Hall), and some small stems of Encrinites. The local dip is plainly northeast, and rapid.

According to Captain Cram's report on the improvement of the Neenah or Fox River, Lake Winnebago is one hundred and sixty-four feet above Lake Michigan; and by C. R. Alston, Esq., the present engineer, one hundred and sixty feet; a difference which arises from their giving the descent of the river, between the rapids, by estimate merely.

At two miles northerly, along the bluff where its foot is apparently about the same elevation above the Lake, the dip is still very apparent, nearly in the same direction as the last, that is, northeast by north. Here, the cliff is composed of a compact, fine-grained, brittle, whitish-gray limestone, regularly bedded in smooth layers, of eight to twenty inches thick, resting on a sandy marl. In this lime-rock no fossils were visible, but in the marl immediately below, they were very numerous, but so soft as to be scarcely recognisable after handling. This greenish marl was almost entirely hidden by large blocks of the white lime-rock, and by a mass of concrete limestone or tufa. One of the fossils appeared to be a *Pterinea,* very indistinct. Another, the *Orthis orbicularis,* analogous to the species of Upper Ludlow rocks of Murchison, or to *Orthis striatula* of the Trenton limestone; a *Cardium striatum* of the Aymestry limestone (Murchison).

* The furrows on this small Atrypa are deep, and perfectly smooth; no stria, either longitudinal or transverse.

The red clay here rises higher above the Lake than in the section, and was mingled with limestone gravel. It also capped the bluffs over the limestone, forming small knobs, from one hundred and fifty to two hundred feet above the Lake. On these knobs are traces of ancient earth-works, which are very common about Lake Winnebago.

These cliffs extend northerly, at apparently the same elevation, to Clifton, which is at the north end of the Lake, thirty miles distant; but I was unable to give them any further examination. At Neenah, opposite Clifton, on the west shore, but little raised above its level, are quarries in low swells of the lime-rock.

For several miles along the low country of the lowest shore, between Oshkosh and Neenah, this limestone is struck in sinking wells, after passing through a few feet of clay. It lies in thin, rough-bedded layers, is of a yellowish-gray colour, inclined to be argillaceous or marly; its fossils scarcely recognisable, except an Orthocera, about two and a half inches in diameter. There are also some undetermined species of Strophomena, Encrinites, and corals. The low ridges appear to result from wrinkles in the upper layers, as if they had been pressed slightly together, at their edges. The lime which is made from this rock, is not very strong, but answers tolerably well for masonry; and the thin-bedded rock makes excellent stone for rough walls.

At the "Grand Chute," the head of which is ten or twelve feet below Lake Winnebago, the lime-rock is again visible, in thin, rough flags, and in thick, coarse-bedded layers, of various colours, varying from yellowish to bluish and whitish-gray. It is compact, or finely subcrystalline, with cavities, containing sulphuret of zinc. Its fossils are very indefinite, but apparently corals. The internal parts of the yellowish layers are blue, like the Cincinnati limestone. The dip apparently northeast, and very slight.

At "Grand Kaukaulin," pronounced by the French, Kok-a-lau; by the Indians, Kau-kon-nee (meaning 'pickerel fishery'), about sixty-four feet above the Lake, is a thick-bedded lime-rock, with a magnesian aspect, dipping rapidly to the south, overlaid as usual by red clay. It has a yellowish-gray colour, is slightly crystalline, and has a few fossils. One of these was very well defined, but broke in getting it out; and another, of the same kind, obtained at Oak Orchard, was lost during the journey up the Oconto. I regarded it, from inspection, as the *Trochus lenticularis* of Murchison; by Hall, called *Pleurotomaria lenticularis,* of the Trenton limestone: the same fossil was found by Dr. Owen in the blue and gray limestone of the Wisconsin River. There were fragments of Orthocera, that resemble the *O. equalis* of the Lorraine shales, and some well-preserved specimens of Pleurotomaria, the apertures excepted. They are one and a half to two inches long, with four and five whorls.

At the lock pit at "Dupere" (a corruption of Des Pères), at the lake-level, the lime-rock is of a bluish-green cast, occasionally yellowish, in flags and thick-bedded strata, of a rough aspect. Here are very large Orthocera, six and eight inches across, but of no great length, with parasitic shells attached. I saw no fossils sufficiently well preserved to determine their species. In the limestone of Frankfort, Kentucky, which is by some regarded as equivalent to the Trenton, there are

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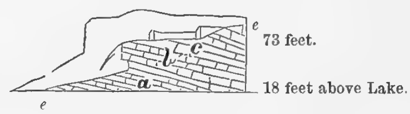
cases of large Orthocera, and also in the Birdseye of New York, just below the Trenton, measuring ten and twelve inches in diameter.

Two miles up the first branch of East River, above Ellis's Mill, three miles from Navarino, the bluish-green and buff limestones, in rough flags, like that of Dupere, are exposed, with a slight dip to the east. At Sturgeon Bay, fifteen miles down the Bay, the buff-coloured limestone rests on the blue limestone of Cincinnati. On the west shore of the Bay, twenty miles from Navarino, at Oak Orchard, the same bluish-green layers are seen about the lake-level, dipping slightly east, containing *Phragmoceras arcuatum* (Murchison, Lower, Ludlow), *Pleurotomaria lenticularis,* and the same large Pleurotomaria as at the Grand Kau-kau-lin. The next appearance of rock occurred at the Falls of the Oconto River, in Township 28 north, Range 19 east, twelve miles from the coast, at Oak Orchard, in a northwest direction.

The foot of the rapid below the Falls, is, by a close estimate of the descent of the river, eighteen feet above the Lake or Bay, thence up to the foot of the bluff, thirty-two feet; thence it is forty-one feet to the surface of lime-rock above the Falls, or ninety-one feet above the Lake; giving a descent in the channel of sixty-one feet in half a mile, of which twenty-two feet, at the saw-mill, is perpendicular.

The following section at the Falls of Oconto River gives the succession of the beds.



e, e. Channel of the river. *c.* Irregularly bedded and siliceous bed, with geodes and crystals, fifteen feet. *b.* Light gray, compact, thick-bedded, close-grained sand-rock, slightly calcareous, twenty feet. *a.* Spotted, yellow and gray, calcareous sand-rock, in thick layers, ten feet visible. The total height above the Lake is seventy-three feet.

The section is taken up stream, or about northwest, towards which there is a slight local dip.

The rock here is so siliceous that there are but few pieces which slake into lime on being burnt. Siliceous matter is not only an ingredient, but exists in white spots, grains, and imperfect crystals. The small yellow spots are iron-rust, of which there is a notable proportion, which turn red on being burnt. Externally, it resembles somewhat the lead-bearing rock, weathering rough, and apparently containing magnesia. It is, however, geologically far below the upper magnesian or lead-bearing rock of Wisconsin. The rock exhibited no signs of veins or veinstone. It was reported by a person engaged at the mill, who had been in the lead region, that he had seen lead in this rock. The composition and structure must be different from that seen at the Falls to produce lead in valuable veins. We discovered no fossils in this rock.

At nine miles, by reckoning along the stream, above the Falls, the lower sand-rock made its appearance in the west bank; its elevation above the top of the last section very little if anything above the upper mill-dam. It rose in a bluff from thence seventy-nine feet (or about one hundred and seventy feet above the Lake), to the general level of the country. At the base, it is a soft, whitish-gray, coarse-grained, crystalline sand-rock, like the St. Peter's saccharoid sandstone, but not as

pure a white. It weathers brown and red, from a mixture of iron, that does not appear to the eye in the fresh fracture, and crumbles into sand.

The upper ledge is more compact, but still soft, and not so white. Interstratified is a thin calcareous bed, in which the structure is completely oolitic. There was no apparent dip to the strata, and the exposure was very limited.

The next place where we were so fortunate as to get a sight of this rock, is on Section 13, Township 22, Range 16 east, on Wolf River, near Bruce's saw-mill, about twelve miles northwest of Grand Chute. Here the calcareous sand-rock of Oconto Falls is seen on the soft gray sand rock, as set forth in the following section.

	Feet.
1. Red clay, on the top of the bluff.	
2. Yellowish-gray calcareous sandstone-rock of Oconto Falls, . .	20
3. Slope, concealed, ...	20
4. Surface of sand-rock of Oconto River, visible, ...	20

The bed of Wolf River is but little elevated above Lake Winnebago, at the entry of Fox River, distant in a direct line about thirty miles; by the river more than twice that distance. The water has very little current, so that I estimate its descent at fifteen feet, the surface of the sandstone at sixty feet more, and the surface of yellowish-gray calcareous sandstone (2), at forty more; making one hundred and fifteen feet above Lake Winnebago, or two hundred and eighty feet above Lake Michigan; and this is apparently as high as any land seen between the Oconto and Wolf Rivers. Concealed in the slope (3), is probably an alternation of siliceous and calcareous strata. The calcareous sandstone (2), is overlaid with ten to fifteen feet of sandy drift, which frequently covers the red clay in low ridges, and furnishes, by mixture, a superior soil.

About six miles southwest by west, in Township 22, Range 15, half a mile south of the Wolf River, the same rocks may be seen in a bluff, facing north, for several miles in length, in the same order, and at about the same elevation.

Probably some of this rock may be found that will slake into lime when burned, but I saw none that I thought would. Its composition is not uniform. No fossils were seen. A bluff of this yellow calcareous sand-rock is reported as existing in the bend of Fox or Neenah River, five miles north of Lake Apukna or Puckana, Township 16, Range 11, which is about on a line to the southwest through the two locations just described. The extension of the compact, yellowish, sandy lime-rock to the west presents more calcareous matter, and becomes a true limestone. Mr. Lapham observed the junction again at Fox Lake, in Township 13, Range 13, Marquette County, and also in Township 10, Range 10, Columbia County; so that the line of junction may be approximately laid down to the waters of Rock River.

Remarks upon the Equivalency of the Eastern and Western Rocks.—The vast field of sedimentary rocks in the United States, embracing the States of Tennessee, Virginia, Kentucky, Pennsylvania, Ohio, Indiana, Illinois, Missouri, New York, Michigan, Wisconsin, and Iowa, the Territory of Minnesota, and the Province of Canada, show everywhere the same general geological features.

Over this immense tract there is a most wonderful persistence of the rocks, when viewed in the aggregate, or by systems. We see everywhere, in the descending order, 1st, the Carboniferous; 2d, the Devonian; 3d, the Silurian Systems, of Europe. In details, they are somewhat modified, and different from the European subdivisions, and from each other. It is therefore to the discussion of local equivalents that geologists are now turning their attention. As there is some discrepancy in the views of different authors, in regard to the relative age of the lower members of the Silurian, in Michigan and Wisconsin, I think this a proper place to add something on that subject, based principally on their order of superposition or stratigraphy; for their palæontology is still but imperfectly known.

In the earlier stages of the investigation, the red and variegated sandstones of Lake Superior were by some regarded as *newer* than the new red; by others, as older than the Potsdam sand-rock. It is now settled that the Lake Superior sandstones are older than the calciferous sand-rock of New York. But do they belong to the same system?

Great changes of level have taken place since the deposition of the Lake Superior sandstones. The Gros Cap Range has been raised; and the granitic and metamorphic masses on the Canada side; from thence by Mamainse to Michipicoten, to say nothing of the great disturbances on the north shore, west of Pigeon River. The great central granitic mass, occupying the central parts of Northern Wisconsin, the oldest rocks of that State, have been broken, tilted, rent, and modified, by igneous action, both metamorphic and trappose. All this, before the uplift of the Keweenaw Trap Range, and at indefinite periods during the deposition of the rocks on the Menomonie, Escanawba, and St. Mary's Rivers. It seems necessary to conclude, that the beds below the Blue Limestone of Cincinnati have, in consequence of these changes, or for other sufficient causes, thinned out, and have been replaced, so as to destroy the continuity of the strata. The uplifts and revolutions manifest at the sources of the Escanawba and Menomonie Rivers, may have contributed to such a result. I cannot regard the rock marked by Dr. Houghton as the "Potsdam Red Sandstone," resting upon igneous rocks on the heads of the Chocolate River, as the same, or as the equivalent of the lower sandstone of the Wisconsin. Formation 1, of Wisconsin, now traced to the Oconto, agrees better with the upper gray sandrock of the Pictured Rocks, which is probably not conformable with the red and variegated sandstone of Lake Superior, on which it rests.

The lower magnesian (F. 2), distinctly traced to the Wisconsin River, is either wanting on Wolf and Oconto Rivers, or has become siliceous, so as to answer better to Dr. Houghton's "Calciferous Sand-rock," occupying a belt of fifteen to eighteen miles wide on the Escanawba, twenty miles from its mouth. In the absence of fossils, I am inclined to call the calcareous sand-rock of the Oconto Falls, the "Lower Magnesian Limestone." If the Blue Limestone of Cincinnati is represented there by the marls which exist near the level of Lake Winnebago, it would strengthen this conclusion. For between the bluffs of Wolf River, in Township 22 north, and the Neenah quarries and exposures at Grand Chute, is but twelve and fifteen miles, on the line of dip within which space we must look for the Lower Magnesian Limestone, if it exists. The calciferous sand-rock of the Escanawba, which I have sur-

mised is F. 2 silicified, and the "upper gray" of the Pictured Rocks, at the St. Mary's River, is reported by Dr. Houghton as wanting; a fact that sustains the theory of a disposition in the lower sedimentary rocks to change, and to thin out. In Canada, to the east of the St. Mary's River, Mr. Logan traces the Trenton directly upon the altered sandstones and conglomerates, which he regards as the Potsdam. It is true, we are not in possession of Dr. Locke's detailed examination of the rocks of this dubious district, but all other reports show that *older* rocks than the New York gain a place beneath the Trenton as we proceed west. I conceive that the Potsdam of Houghton, on Chocolate and Train Rivers, terminates against the metamorphic and Plutonic rocks at the northeast of the Falls of the Menomonie River, and does not pass into the sandstone of the Menomonie, which crosses below the "White Rapids." Not having personally examined the sandstone of the Menomonie River, I cannot speak of its identity with F. 1, of the Wisconsin Reports, but regard the soft sandstone of the Oconto and Wolf Rivers as a part of that formation, probably the upper or newest portion.

Whether the Lake Superior red sandstone is older than F. 1, I cannot say, but incline to think it is, and certainly older than the calciferous, which rests upon it. It may be asked why, if the Lake Superior red is not conformable, and is distinct from the New York system, as developed between Lake Michigan and Superior, it should be found in Canada beneath the Trenton limestone? To this I should reply, that it may there be beneath it, and not be conformable, as well as at the Pictured Rocks; and that the convulsions attending the uplift of the Gros Cap Range were such as to break off and detach a portion of the Lake Superior red sandstone; and consequently its dip, after that, was a matter of accident, not dependent upon its original deposition. In all other parts of the Lake, with exceptions no greater than must be expected in volcanic districts, the dip of this sand-rock is generally to the southeast, at various angles; and undoubtedly this rock forms the bed of Lake Superior. If it is the same or the equivalent of F. 1, it should somewhere contain fossils, especially on the Upper St. Croix, where they approach so near each other as a few miles, only separated by a trap outburst.

CHAPTER III.

RED CLAY AND DRIFT OF GREEN BAY AND WISCONSIN.

One of the most striking geological features of the region of the great North American lakes is the universal presence of loose diluvial matter, deposited since the convulsions that have taken place in the metamorphic and igneous rocks. Although the general elevation of the superficial materials is not very different, each lake seems to have a system of its own, differing in colour and stratification from the rest. On Lake Champlain and the valley of the St. Lawrence, to a height of five hundred feet above the ocean, marine shells are found in the drift. On Lake Erie, the beds of marly clay and sand which surround its western half, elevated from five hundred to six hundred and fifty feet above tide-water, are almost destitute of shells; and those rare ones yet found are fresh-water and land shells. These are a Planorbis and a Helicina, found by myself in the "blue marly clay" stratum at Cleveland, fifteen feet above the lake-level, the same I had seen in the Loess of New Harmony and St. Louis.

The Lake Erie System extends across Canada and Michigan, by way of Lake St. Clair and the River St. Clair, to Lake Huron, and embraces a portion of its southern extremity.

Rising from Lake Michigan there is another deposit, covering a large tract in Wisconsin, of a very different external cast. This is the "red clay" deposit, which is seen at Milwaukie on the south, and traced by me without interruption to the Falls of Wolf River. At Sheboygan, it extends more inland than at Milwaukie, and is seen to the foot of the high gravel ridges dividing the waters of Sheboygan River from those of Rock River and Lake Winnebago. After crossing this ridge, it reappears in the valley of Lake Winnebago, at an elevation of one hundred and fifty to two hundred and fifty feet above its surface, equal to four hundred and ten feet above Lake Michigan, or nine hundred and eighty-five above the ocean. The valleys of Lake Winnebago, and the Fox (or Neenah) and Wolf Rivers, and the peninsula between Lake Michigan and Green Bay, are composed of this clay; and it is so uniform in its composition and colour, that specimens taken from Lake Shawano, and Lake Winnebago, from Green Bay or Milwaukie, could not be identified if the labels were misplaced. It is so argillaceous, that bricks are everywhere made

of it, except at Milwaukie, where it appears to thin out on the south. I noticed in all the brick-kilns that the arch-brick, and those adjacent, which were very hard burnt, took the dull-white or cream-colour of the Milwaukie brick, but not with as clear and pure a tint.* The iron contained in the clay collects in black, vitrified, irregular spots or blotches, leaving the remainder of the brick of a whitish colour. Those not so severely heated retain a fair red colour. The famous Milwaukie brick are made from another deposit, also containing iron, but in a different form, which separates by heat in the same manner, but with much less intensity, so that almost all the bricks of the kiln are white.

The red clay of Lake Michigan differs from that of Lake Superior in being more ductile and tough, in not being marly, and it seldom has interstratified beds of gravel, being homogeneous and persistent. At Milwaukie, and near the Falls of Wolf River, near its extreme borders north and south, it is somewhat mingled with beds of coarse gravel; and also on the bluffs north of Tayhedah, on Lake Winnebago, near its superior face or greatest elevation. It makes a good wheat soil, especially where, as is frequently the case, there is a shallow stratum of sandy matter on its surface. Its age cannot as yet be determined, for want of fossils. At Appleton, on the Fox River, in a well, pieces or splinters of well-preserved wood were found at the depth of thirty feet.

It is remarkable that the heavy clay and marly deposits of Lake Erie, Lake Michigan, and Lake Superior, are found in their principal force, on the *west* sides and ends of those fresh-water seas, and that the presumption is, that the deposits themselves are all from fresh water, and very recent.

It is in the red clay of Wisconsin that the inhabitants of the towns on Fox River sink their Artesian wells.

Artesian Wells.—The village of Fond du Lac is situated on the red clay, not much elevated above the level of Lake Winnebago. The clay being compact, and impervious to water, did not give to ordinary wells anything like living water. They served only as the receptacle of surface-water. The idea was conceived of boring into the clay to greater depths than ordinary wells. Mr. A. Curtis undertook the work for Mr. G. M'Williams, and the plan succeeded remarkably well. There were (October, 1849) eighteen of these wells in the village, varying in depth from seventy to one hundred and ten feet. Mr. Curtis informed me that the order of stratification is everywhere the same, and reckoning in the descending order, as follows:

	Feet.
1. Red marly clay,	30 to 40
2. Blue clay, with strips of quicksand,	40 to 60
3. Sand and gravel,	1 to 3
4. Lime-rock (Silurian).	

* Some of the Fond du Lac clay (Specimen 99) is said by the workmen to contain too much lime to stand the heat of the arches. Dr. Owen's analysis of the red clay of Bad River, Lake Superior (Specimen No. 46 of my collection), gave protoxide and peroxide of iron, 10·7 per cent., which, by burning in the fire-place, makes a good fine-grained red brick; while the cream-coloured, hard-burnt brick (Specimen 98 of my collection), from Neenah, on the Fox River of Green Bay, gave a still greater percentage of iron, and this red clay, when *moderately* burnt, is *red*, when *hard-burnt* is *cream-colour*.

Mr. George M'Williams (who, I am told, caused the first well to be made) informs me that, "At the depth of ninety feet, the drill struck a bed of sand and gravel, of various colours, and the water gushed out with such force as to throw out gravel, as large as a pea, and sand. In the course of half a day it became clear." Mr. M'Williams estimates the discharge at one gallon per second, without any perceptible change in the quantity. In July, the temperature was 48° Fahrenheit; and in January, 1850, when the mercury in the air was at 20° Fahrenheit, the water in the tube was 51° Fahrenheit. If it shall be found, on further examination, that the water in these wells is of higher temperature in winter than in summer, a point of some theoretical interest will arise as to the cause of the change. At Oshkosh, in a well fifty feet deep, I found the water at 48° Fahrenheit in September.

The discharge of water from the Fond du Lac wells is much more rapid in some than others. At Oshkosh, twenty miles north, also on the margin of the Lake, they have bored a few, but they do not give as much water as at Fond du Lac; the depth is from thirty to sixty feet, and in the same strata as at Fond du Lac, to wit:

	Feet.
1. Red clay,	20
2. Blue clay and quicksand,	30
3. Sand and gravel (water stratum), a few feet.	
4. Lime-rock.	

At Neenah, at the north end of the Lake, their depth is not so great. One of those at Oshkosh became dry during the fall.

Attempts have been made at Appleton, at the foot of the Grand Chute, but the water does not rise to the surface. This no doubt is owing to a stratum of sand and gravel underlying the red clay at the depth of thirty and forty feet. Through this open stratum, the water would flow into the river, not being confined on that side by surrounding impervious strata. At Green Bay, the water has not yet (October, 1849) been struck in such force as to flow over. The following is the order of strata penetrated there by Mr. Curtis.

	Feet.
1. Red clay,	72
2. Quicksand (with water),	2 to 3
3. Hard pan—sand and clay cemented,	6
4. Red clay,	1
5. Hard pan,	4
6. Red clay,	1
7. Hard pan,	½
8. Red clay,	20
9. Lime-rock—Silurian.	
	107½

The boring is effected by a heavy four-inch drill, worked with a spring-pole, as in salt borings. The cost is seventy-five cents to a dollar per foot. In the Green Bay well no water was struck below the quicksand bed, No. 2. The stream from

some of the Fond du Lac wells pours forth with such strength as to make a little rivulet, and might, if confined, be raised many feet. They find it necessary to tube the hole only a few feet down, as the clay keeps its place well. The water is excellent for drinking, and tolerably soft. The base rock at Fond du Lac, and probably at Oshkosh, inclines to the southward. The reservoir in these cases is in the coarse gravel that covers the lime-rock, confined by the impervious clays above. The country on the southeast rises rapidly in a bluff of two hundred feet, composed of lime-rock, against which the clay and drift abut. On the south and southwest, the surface rises more gradually; and on the north and northwest, the rise is still less. The surface of the Lake is lower than the top of the wells, so that the supply must be looked for in the adjacent country, and we must also suppose that there is no connexion between that source and the Lake; for if there was, it would discharge there, and rise no higher. The clay doubtless forms the bed of the Lake, about the southern half, and is not penetrated by its waters. If such was the case, the temperature of the adjacent wells would be expected to change with the temperature of the Lake.

The sections of the red clay shown by these borings, and some others, taken at the bank of the Lake, and at various bluffs, separated one hundred and fifty miles from each other, prove that here, as on Lake Superior, there are bands and strata of sand and gravel, intermingled with the red clay. Here, as there, boulders are scarcely ever seen resting on the clay; that is, where the clay is the surface material; and also, that the high drift ridges are composed of coarse materials, and support boulders of Plutonic rocks.* The drift-hills between Sheboygan and Fond du Lac are, by estimate, three to four hundred feet above Lake Michigan. They are composed mostly of limestone, very coarse gravel, and chert, but with occasional pieces of quartz and other igneous rocks. The boulders are quartz, syenite, granite, greenstone, black and red trap, hornblende, augite, and limestone. As you rise above the red clay, the wells along the road indicate a graduation into a whitish, marly clay, that gives a very strong soil. The drift-hills no doubt overlie the red clay. They show large tracts of country, covered by steep conical pits, without water, that are called "potash kettles," twenty, fifty, and eighty feet deep.

In the red clay banks on the east shore of Lake Winnebago, three miles north of Tayhedah, are beds of limestone and gravel, intermingled with the clay. The shore of Lake Michigan, from Milwaukie to "Death's Door," exhibits the stratification of this deposit very satisfactorily.

At Milwaukie, it rests on coarse gravel drift. At Sheboygan, at the water's edge, we find—

	Feet.
1. Red clay, "hard pan," with half-worn pebbles of granitic rocks and cherty limestone (springs of water along the upper edge), ...	20 to 25
2. Sand and small gravel, ...	10 to 15
3. Coarse yellow sand forming the surface—thickness irregular.	

* On the low red clay ground between Oshkosh and Neenah there were more boulders of northern rocks resting on the clay than were seen anywhere else.

At Grand Chute, on the Fox River—

	Feet.
1. Red clay, ...	30
2. Coarse sand and gravel drift, ...	20
3. Limestone, Silurian.	

Three miles below the Falls of Wolf River, the coarse sandy drift of the falls begins to show red clay, sometimes mingled in confusion, and at others in alternate beds, containing granitic pebbles, as well as those of limestone. This fact, and others that fell under my notice, indicate a current from the south and southwest during a portion of the diluvial epoch. Descending Wolf River to Oshkosh, the red clay was found to occupy its valley, with beds of coarse yellow sand, or of gravel, on its surface, or interbedded near its surface. These variations in the composition of the drift are probably owing to changes in the intensity, direction, and force of the diluvial currents.

About the heads of the west fork of the Oconto, are long, mountain-like ridges of sandy drift, rising one hundred and fifty and two hundred and fifty feet above the streams, destitute of water, and covered with heavy birch timber. On these uplands are immense blocks of red syenitic granite, with a large proportion of felspar; their diameters ranging from five to twenty feet. There are large tracts of these drift-beds covered with sink-holes of irregular forms, but inclined to be circular, from ten to one hundred feet deep, with steep sides, and without water. They look like a field of mounds or "moraines" *inverted*, the ridges sharp-cut and very thin; a mere ridge between one and its next neighbour. The boulders are more numerous on the narrow spaces between these cavities than they are in them, and the timber grows in as well as out of them. The side view, at a little distance, resembles the form of a highly agitated sea suddenly made immovable and solid. They are not the results of currents of water and eddies, depositing sediment in basins. The sides are too steep, the form being conical or funnel-shaped, and the ridges between them incapable of resisting even a moderately flowing current of water. The thought that took possession of my mind on the spot was, that a mixed mass of ice and drift had been placed there, the former thawing out after deposition, and after the retiring of the waters. Dr. Beach found similar appearances on the head waters of the eastern fork.

CHAPTER IV.

SECTION I.

REMARKS ON THE BAROMETRICAL OBSERVATIONS.

My barometer was a new syphon, by Bunten, not compared with any other barometer. It has not been practicable to carry it everywhere during the explorations, sometimes because of the extreme risk which such a fragile instrument undergoes in a rough region of precipices, swamps, rivers, and thickets, and at others, from the necessary delay it occasions when time is to be economized.

For heights on the Penokie Range, by observations not near each other in regard to time, I have adopted as a base the average of sixty-nine readings at the lake-level during two months, the elevation of the Lake being assumed at six hundred and twenty-four feet above the ocean,—its true level not being yet determined.

The season was very wet and cloudy, and in the mountain region, rains, particularly thunder-storms, occurred when the weather in the lowlands and on the Lake, a few miles distant, was calm and clear. I should have adopted two bases, one for fair weather and one for foul, if my observations had not shown nearly as great variations in the height of the mercury, during weather and winds apparently the same, as between fair and foul. In a region like that opposite La Pointe, where a high range of mountains, within fifteen and twenty miles, overlooks a flat country, and the Lake, the barometer appears to be influenced by causes that cannot be perceived and noted at the time of the observation. Storms, winds, and clouds, not visible to the eye, may yet be within the range of action upon the mercurial column. Thus, on the 14th of July, at fifteen feet above lake-level, ten miles from the Lake, on Bad River, at 12½ P. M., the column stood at 75·82 millimetres; attached thermometer, 61·4° Fahrenheit; detached, 61°; breeze, southeast; clear. On the 20th of August, seven feet above lake-level, 11½ A. M., barometer, 74·07; attached thermometer, 68·6°; detached, 70°; breeze, southeast; clouds 8. This is the extreme range of my readings, and the circumstances, excepting clouds, apparently the same. My elevations, many of them the result of a single one, or of but a few observations at each point, and often in heavy weather, must be looked upon as approximations only; in fact, all calculations from a single barometer, without

consecutive basal readings, must be so regarded. At the crossing of the Penokie Range, between the branches of Tyler's Fork, the observations were good, and sufficient in number.

The mean of sixty-nine readings, at lake-level, is—barometer, 74·93 millimetres = 29·50 inches; attached thermometer, 67·1°; detached, 66·9°.

The section through the drift-hills west of La Pointe, was made by referring the upper station readings to a base obtained at each extremity of the line, the weather being cloudy and windy all the way. These are the least satisfactory of any.

SECTION II.

THERMOMETRICAL READING AND CLIMATE.

Being a large portion of the time in thick woods, it was not practicable to note with accuracy the state of the clouds, or the direction and force of the winds.

FOR JULY, 1849.

Mean of twenty morning observations gave,	58·9° Fah.
" nineteen noon " "	68·3°
" twenty sundown " "	65·2°
Lowest in the morning,	43·5°
" at noon,	52°
" at sundown,	56°
Highest in the morning,	78°
" at noon,	81°
" at sundown,	78°

There were eight heavy rains, with thunder: four from the southwest, two from the northwest, and two from the west. Course of the wind: twice from the northeast, eleven times from the northwest, eight times from the southeast, ten times from the southwest, three times from the south, four times from the north, four times from the west, and twelve times calm.

FOR AUGUST, 1849.

Mean of nineteen morning observations gave,	54·7° Fah.
" sixteen noon " "	64·5°
" fourteen evening, " "	63°
Lowest in the morning, " "	36°
" at noon, " "	50°
" sundown, " "	50°
Highest in the morning, " "	72°
" at noon, " "	80·5°
" at sundown, " "	71°

There were nine rainy days. Wind from the southwest seven times, from the southeast three times, from the northeast three times, from the northwest four times, from the west eight times, from the north-by-west once, from the east once. Calm thirteen times.

These results show a remarkable equanimity of climate.

On the morning of the 4th of August, there was, on the red clay plains, ten miles from the Lake, a light frost. I once saw a heavy frost on the Fire Steel River,

east of the Ontonagon, on the 13th of July, such as to kill garden vegetables. The same year (1846), the fall frosts did not occur, so as to freeze water, till October 5th. Forty and fifty miles south of the Lake, at the sources of the rivers that run to the Mississippi, the weather is represented by all traders to be much more severe and more variable than it is near the coast. The volume of water is so great, as to act in a controlling manner upon the temperature of the surrounding country.

In winter, it does not freeze till late, allowing of navigation in December; and in summer, it feels the increase of temperature slowly. Off Keweenaw Point, in July last, the surface-water was found to be 37° Fahrenheit. As this is near the degree of greatest density of water, a reason may be assigned why the waves of Lake Superior produce greater effects upon the shore than those of the Lower Lakes, the water being heavier during the summer months.

The approximate mean of the two warmest months of the summer of 1849, has been given above. It indicates a moderate and delightful summer climate.

I am able to add the observations of the army surgeons stationed at Fort Wilkins, from June, 1844, to June, 1846, taken from their reports to the Surgeon-General at Washington.

July, 1844.—Sunrise, 56·77°; 9 A. M., 64·38°; 3 P. M., 72·03°; 9 P. M., 60·03°.
August, 1844.—Sunrise, 57·70°; 9 A.M., 64·19°; 3 P. M., 69·80°; 9 P. M., 60·70°.
July, 1845.—Sunrise, 58·0°; 9 A.M., 64·87°; 3 P. M., 71°; 9 P. M., 61·32°.
August, 1845.—Sunrise, 68·48°; 9 A. M., 62·85°; 3 P. M., 67·41°; 9 P. M., 57·48°.

The greatest range in the morning monthly mean for three years, 1844, '45, '49, is 14°, during the two hottest months of the year. The greatest difference of all the observed monthly means above given, is 18°.

Without going over all the observations in detail, we may get an idea of the other extreme of the season, by an abstract of the three coldest winter months, taken from the surgeons' report.

December, 1844.—Sunrise, 20·93°; 9 A. M., 22·45°; 3 P. M., 25·09°; 9 P. M., 22·22°.
January, 1845.—Sunrise, 19·96°; 9 A. M., 21·70°; 3 P. M., 23·61°; 9 P. M., 20·32°.
February, 1845.—Sunrise, 20·96°; 9 A. M., 23·03°; 3 P. M., 28°; 9 P. M., 22·82°.

The lowest point in December was 6° above zero,—in January and February, zero.

December, 1845.—Sunrise, 16·38°; 9 A. M., 19·06°; 3 P. M., 20·12°; 9 P. M., 18·16°.
January, 1846.—Sunrise, 23·29°; 9 A. M., 25·03°; 3 P. M., 28·74°; 9 P. M., 24·54°.
February, 1846.—Sunrise, 16·35°; 9 A. M., 18·53°; 3 P. M., 23·32°; 9 P. M., 18·17°.

In December, the lowest was 4° below zero; in January, 2°; in February, 9° below. The 24th, 25th, and 26th, ranging from zero to —9°.

The observations are not continued over a sufficient number of years to fix the average of the climate, but show a much more moderate winter than would be anticipated in latitude 47½° north. The post was evacuated at the beginning of

the Mexican war, and has not been occupied since, which is the reason of the cessation of the report of the surgeons.

The two months of June and September of the years above given, vary very little from each other in the monthly mean. From the time snow falls in November, till it disappears in May, the ground is covered, from eighteen inches to four feet in depth, but is never frozen. By an account kept in the winter of 1848–49, at the mouth of the Ontonagon River, the total fall of snow was *thirty-nine* feet, but it was known to be much beyond the average. There are no winter rains, but a great deal of dull sky, from frequent falls of snow; yet residents suffer little from cold, owing to the uniformity of the temperature. The under surface of the snow, resting upon unfrozen ground, continually wastes away, and causes the mass to settle more or less every day. The agents of the Fur Company, and the miners, travel comfortably from place to place on snow-shoes and dog-trains or sledges, encamping at night in the thick forest.

I know of nothing in the climate of the Bad River country, to prevent the successful cultivation of wheat, and a considerable portion of the soil is favourable for that grain.

CHAPTER V.

LUMBERING ON THE WATERS OF GREEN BAY.

The business of making lumber, on the waters which discharge into Green Bay, is now very extensive, and is every year becoming more so. By inquiry and observation as to the number of saws now plying (October, 1849) on these streams, I put them at forty-six, and find that twelve additional ones will be in operation this fall or winter; making in all fifty-eight.

These are distributed as follows:

	Saws.	Building.
On the waters of Wolf River, ...	8	
" " Fox River (below Lake Winnebago), . .	7	6
Other streams discharging into the Bay, including the Menomonie,	26	4
About Lake Winnebago (three of which are steam mills), . .	5	2
	46	12

There are several mills, that do a limited business, not included in the above statement, because no good estimate can be made of the quantity of lumber cut by them. Those large merchant mills on the Oconto, Pensaukie, Peshtega, and Menomonie Rivers, do not run in the winter, as a general rule; and during the summer season are kept in motion night and day.

Each saw turns out from four to five thousand feet in twenty-four hours; but some of those included above, are not capable of cutting four thousand feet per day, and do not run incessantly. To arrive at the amount of lumber made, I think an average of four thousand feet to each saw, for one half the year, or one hundred and eighty-two days, would not be too high.

Some very good mills exceed five thousand feet, but others, and greater numbers, fall short of four thousand.

At four thousand feet a day, for one hundred and eighty-two days, we should have 33,488,000 feet of lumber as the product of the year 1849, worth, at $6 per M., $200,928.

Although this calculation may appear large, I leave it as the result for 1849, because some of the new mills will do business this fall.

It is difficult to calculate the amount of laths and shingles produced, in the lumber region under consideration. There are about three mill-saws for one circular or lath-saw; although I believe each mill of two upright saws has a lath-machine, which cuts up all the slabs and waste timber.

The lumber of Wolf River, of Lake Winnebago, and of Fox River, is all consumed at the numerous villages on those waters, springing up with hot-bed rapidity. None of it is shipped, but on the contrary, boards are brought into Fox River from mills down the Bay; so that, probably, not more than one-third of the lumber produced is taken out of the Bay to the Lake towns, or 11,000,000 feet.

No better evidence could be produced of the surprising growth of the Fox River country. From the best information within my reach,—which is, however, very indefinite,—I think it requires twenty men during the year to produce a million of lumber, or six hundred and seventy labourers in all.

The saws that are driven by water, are fixed in the old-fashioned frame or gate. I saw none of the "Muly" or patent saws. The expense of erection varies very much,—from $1800 to $2300 a saw.

The pine trees from which this lumber, lath, and shingles, are made, are nearly all taken from the public lands. From my observations on the Oconto and Wolf Rivers, and from reports of the timber on the head waters of the other streams, the supply will be sufficient for thirty years, although becoming less accessible every year.

It is reported that there are nine saws in operation, and two more in process of erection on the waters of Green Bay and Bay de Noquet, to the eastward of the Menomonie, in the State of Michigan, making, when all are completed, sixty-nine saws and about thirty lath-machines on the waters discharging into the Bay.

Lumber from Michigan and Wisconsin now passes through the Illinois Canal, in considerable quantities, to the Mississippi River and the towns on the Illinois River, and is said to be of better quality than that received from the Upper Mississippi.

I am aware that my results show a greater product for the number of saws here than in the mills on the Wisconsin, Black, Chippewa, and St. Croix Rivers, as shown by Mr. Randall, in the Report for 1847. It is possible that the Green Bay mills run more at night, and the timber is better for the sawyer, as the lumber is said to be for the joiner and carpenter.

According to Mr. R., forty-five saws on the Wisconsin turned out nineteen and a half millions, and thirty-five saws on the other principal tributaries, nineteen millions of feet. If these mills lie idle half the time, and run day and night the other half, the average of the Wisconsin mills was about 2200 feet, and of the others 2600 feet per day of twenty-four hours.

None of the lumbermen with whom I conversed rated their mills at less than 4,000 feet to each saw; others were put at 5,000; and one at 6,000.

Many of the country, or "custom saw-mills," which are frequently weak in power, not being built on the best plan, nor kept in good order, cut two thousand feet of pine lumber by daylight. The merchant mills generally have an abundance of

water, with machinery well constructed; and if by breakage, ice, or other hindrances, they are not compelled to lose more than half the year,—which I have no reason to suspect they do,—should come fully up to an average of four thousand feet per day.

The manager of one of the steam-mills, having a "Muly" saw, thought he could turn out, with clear logs of good size, 12,000 feet to a saw in twenty-four hours. There are water-mills in Maine that average more than six thousand. Although a part of my estimate is open to conjecture, I think it does not vary materially from the truth, and that an increase of one-third may be expected for the year 1850, raising it to 45,000,000 feet.

At the mills at the Falls of the Oconto River, I saw a very ingenious mode of passing lumber by a rapid, of half a mile in length and about sixty feet fall. It was a wooden canal or trough, constructed by Mr. Ingham, about four feet wide and one foot deep, into which the water from the tail of the mill flowed. The lumber was passed into this race by pieces, or boards, gliding swiftly and safely through its whole length into the still water below. Even a canoe freighted with ladies has been known to descend the chute by this mode of navigation.

DR. B. F. SHUMARD'S REPORT.

GEOLOGICAL REPORT

OF

LOCAL, DETAILED OBSERVATIONS,

IN THE VALLEYS OF THE

MINNESOTA, MISSISSIPPI, AND WISCONSIN RIVERS,

MADE

IN THE YEARS 1848 AND 1849,

UNDER THE DIRECTION OF

DAVID DALE OWEN,

UNITED STATES GEOLOGIST.

BY B. F. SHUMARD,

HEAD OF SUBCORPS.

TO DAVID DALE OWEN, M.D.,

UNITED STATES GEOLOGIST.

SIR: Herewith is submitted my Report of the detailed surveys assigned to me on the St. Peter's, Mississippi, Wisconsin, and Barraboo Rivers.

Yours, &c.,

B. F. SHUMARD.

DR. B. F. SHUMARD'S REPORT.

CHAPTER I.

DETAILED OBSERVATIONS ON THE ST. PETER'S AND ITS TRIBUTARIES.

All preliminary arrangements having been made, we commenced our ascent of the St. Peter's or Minnesota River on the morning of the 31st of May, 1848.

Our starting-point, the Bluffs of Fort Snelling, consist, as shown elsewhere by local sections, of fossiliferous limestones, F. 3, A, reposing on soft white sandstone, F. 2, C. This formation continues in view only for half a mile above the mouth. Beyond this the rocks are hidden from view for many miles by drift and soil, but the contour of the hills indicates the existence of the shell limestone as their nucleus for some distance beyond its last outcrop.

The alluvial lands near the mouth of the river are rather low and wet, and are overflowed in periods of high water. They form, however, excellent meadows, and support a growth of good grass. The St. Peter's winds through the flats to Ewing's Trading-Post, about ten miles above the mouth. At this point the hills have an elevation of one hundred feet above the river, and seem to be composed chiefly of transported materials of sand, gravel, and small boulders. The alluvial bottoms are from half to three-quarters of a mile in width, and from four to eight feet above the ordinary stage of water; on either side the upland prairie rises in graceful swells from seventy-five to one hundred and fifty feet above the river, the soil of which, though rather arenaceous, is of good second-rate quality, well adapted for the growth of oats.

Six miles above the mouth, Credit River, a small stream flowing from the south, enters the main river, and one mile farther, on the left, is a range of gently sloping drift-hills, covered with a luxuriant greensward.

Eight miles above this point, and, by estimate of our voyageurs, twenty-five miles from Fort Snelling, is Shacopee's village, inhabited by a band of Sioux Indians.

It is situated on the south side of the river, on an elevated bench of land, twenty-five feet above the water-level.

Immediately in front of the village is the first exposure of beds belonging to the Lower Magnesian Limestones witnessed in the ascent of this stream. The strata are twenty feet high, and appear to lie horizontal. At the base of the section is a thin seam of siliceous oolite, on which rests a layer of compact sandstone, made up of small, transparent, angular, and rounded grains, cemented by a calcareous paste; above this we have intercalations of magnesian limestone, and magnesio-calcareous sandstone, surmounted by thick-bedded, buff-coloured magnesian limestone, containing imperfect casts of a *Pleurotomaria* (?), apparently of the same species as one found in similar beds on the St. Croix, near the point where the Correction Line crosses that stream. The rocks at this exposure correspond in lithological appearance with those observed towards the base of the section at the Falls of Willow River.

Five miles above, on the right bank of the river, the uppermost layers of the same beds again appear, forming a low ledge, four to five feet high.

Five or six miles still further up the stream, at "La Petit Prairie," we observed an accumulation of granitic and trappean boulders, extending for a short distance along the shore. The timber improves in appearance in advancing up stream. Below Little Rapids, a portion of the alluvial lands is well covered with elm, maple, ash, box-elder, and cotton-wood.

At the Little Rapids, about fifty miles above the mouth, the river has a fall of several feet over thick-bedded quartzose sandstone. The rock is of a brownish colour, composed of coarse, incoherent grains, and when struck with the hammer, it crumbles readily to sand. About a quarter of a mile above this place is another rapid, made by this sandstone; and a few hundred yards still further, on the right bank, the same rocks again appear, forming a low ledge, elevated five feet above the water-level. It is stated by Mr. Featherstonhaugh, that this sandstone corresponds with that which occurs at Fort Snelling.* It will be seen, however, as we proceed, that its true position is beneath the Lower Magnesian Limestone, and therefore several hundred feet lower in the series than the white sandstone at the mouth of the St. Peter's.

One mile above the last exposure, on the left bank of the river, and a few hundred yards from the shore, we found the soft, brown sandstones of the rapids overlaid by the inferior members of the Lower Magnesian Limestone, the latter resembling the beds which occur at Shacopee's village.

After passing this exposure we did not meet with any of these Lower Silurian rocks *in situ*, for the distance of nearly twenty miles, following the windings of the stream.

About ten miles above The Rapids, two beautiful terraces of fertile prairie rise above the river-bottom. The summit of the first bench is elevated one hundred and thirty feet above the river, and extends for several miles up and down the river, with a width of about three-quarters of a mile, dotted with occasional groves of oak, maple, and elm trees. The second terrace rises one hundred feet higher, or

* Report of a Geological Reconnoissance, etc., etc., by G. W. Featherstonhaugh—1835.

two hundred and thirty feet above the river, and is composed of coarser materials. The view from these heights is exceedingly fine, and the disposition of prairie and groves of timber almost conveys the idea of a cultivated country.

The commencement of what is designated the "Bois Franc* District," sets in above this, and extends for the distance of about forty miles along the course of the stream, and is probably the best agricultural region on the St. Peter's.

Some singular rounded drift-hills were observed in this vicinity, supporting a heavy growth of tall grass, with a few isolated trees on their summits. Some of these are so regular in their outline, that they might almost be mistaken for ancient earth-works, such as are common on the Upper Mississippi further south.

About five miles beyond the mouth of Witakantu River, a small stream coming in from the northwest, and a little below Abert's Run, we found, on the right bank of the river, the "fawn-coloured limestone" mentioned by Featherstonhaugh. The rocks at this place are exposed to the height of eighteen feet above the water-level. In the ascending order there is, first, ten feet of rather thick-bedded salmon-coloured magnesian limestone, somewhat cellular, the cells being coated with carbonate of lime; then succeeds two feet of magnesian limestone, in layers varying from a half inch to two inches in thickness, succeeded by six feet of intercalations of sandstone and magnesian limestone, on which rests the drift, which has a thickness of over one hundred feet.

We could not discover any organic remains in the strata at this place, but in lithological aspect they so closely resemble the beds of passage between the Lower Sandstone and Lower Magnesian Limestone on the St. Croix and Upper Mississippi Rivers, that even in the absence of fossil data, little doubt could be entertained as to their geological position.

Above this place the river has a very tortuous course, and the hills increase somewhat in elevation. At the mouth of a small stream, which the voyageurs called Beef Creek, the altitude of the table land is two hundred and eighty feet above the river; on the surface are numerous erratics, from a few inches to several feet in diameter. They consisted chiefly of granite, gneiss, porphyritic and greenstone trap.

Above Bois Franc Creek, the hills near the river have an elevation of about one hundred feet, with a very gradual slope towards the margin of the water; but at the distance of a mile and a half back, we observed other ranges running parallel with the river, which seemed to be from eighty to one hundred feet high.

At "White Rock Bluff," situated on the right bank of the river, about six miles below Traverse des Sioux, is an interesting exposure of the Lower Magnesian Limestone and Lower Sandstone. The height of the bluff is seventy-two feet above the water-level. The succession of the beds here in the ascending order is as follows:

	Feet.
1. Talus, covered with fragments of sandstone and magnesian limestone,	30 to 40
2. White and brown sandstone, composed of rounded, rather coarse, semi-transparent grains of quartz, loosely cemented, . .	20
3. Green siliceous earth, ...	1

* The *Bois Franc* is a term used by the Canadian French to designate the deciduous from the evergreen trees.

	Feet.	Inches.
4. Seam of grayish oolitic chert, with a thin incrustation of whitish decomposing chert, ...		2 to 3
5. Light salmon-coloured magnesian limestone, with dendritic markings, and cavities lined with crystals of calcareous spar, in layers from a few inches to two feet in thickness, containing Lingulæ, Orthis, and Trilobites, ...	11	

The magnesian limestone at this locality does not differ essentially in appearance from that noticed near Abert's Run.* It contains two kinds of Lingulæ; one, an elegant little species, of an ovate shape, with fine concentric striæ, is not distinguishable from *Lingula Dacotaensis,* a form which characterizes the Lower Magnesian Limestone, at the quarry near Stillwater, and other localities throughout the Chippewa Land District; the other, of which we obtained only a few fragments, is much larger, but the specimens are so imperfect, that the characters of the species cannot be made out. Associated with these Lingulæ, we found the cast of a small *Orthis,* with fine radiating striæ, and portions of the cephalothorax of a Trilobite, related to the family *Olenidæ.*

Between White Rock and Traverse des Sioux, the land is high and rolling, and, in general, well timbered with elm, oak, hard and soft maple, white and black walnut, ash, and linden. The banks of the river are, usually, from eight to ten feet high.

Boulders, chiefly of granite, syenite, and porphyritic and greenstone trap, occur in great profusion, scattered over the surface of the upland prairie, but we did not notice any exposures of stratified rocks. The Lower Sandstone, F. 1, doubtless forms the nucleus of the hills, since, in digging a well at Traverse des Sioux, near the house of the Rev. Mr. Hopkins, thirty feet above the river, this rock was struck a few feet below the surface. And one mile beyond Traverse des Sioux, the same sandstone appears in the bed of the river. The rock is rather fine-grained, of a light buff colour, and has numerous brown spots disseminated. It is more compact than the sandstone occurring at White Rock. One of the layers is highly charged with casts of *Euomphalus Minnesotensis.*

Two miles above Traverse des Sioux, the sandstone exhibits a nearly perpendicular face of twenty feet, towards the river; and two miles still further up it forms solid ledges, twenty-five feet thick, capped with twenty feet of magnesian limestone. In the sandstone we found with the above *Euomphalus,* the pygidium of a small Trilobite, but the rock was of such a friable character, that we were not able to preserve specimens. The magnesian limestone contains *Lingula Dacotaensis,* and remains of a species of Trilobite, apparently identical with that occurring at White Rock. We could not perceive any dip in the strata at this section.

* The composition of this magnesian limestone is as follows:

Carbonate of lime, ...	58·65
Carbonate of magnesia, ...	29·15
Insoluble matter, ...	7·25
Alumina, oxide of iron, and manganese, ...	1·55
Water, ...	2·65
Loss, ...	0·75
	100·00

At the head of a small island, about three miles beyond, the same rocks were again observed jutting out at intervals from the slope of a hill on the left bank of the river.

After proceeding about three miles further, we reached Mankassa, or White Earth Bluff, situated on the east side of the Minnesota. It is a perpendicular escarpment seventy feet high, fifty-five feet of which is white and brown sandstone, and fifteen feet of rather thin-bedded magnesian limestone; the two formations being separated by a thin seam of green siliceous earth. There is, therefore, a rise in the strata of about thirty feet between this point and that of the last section.

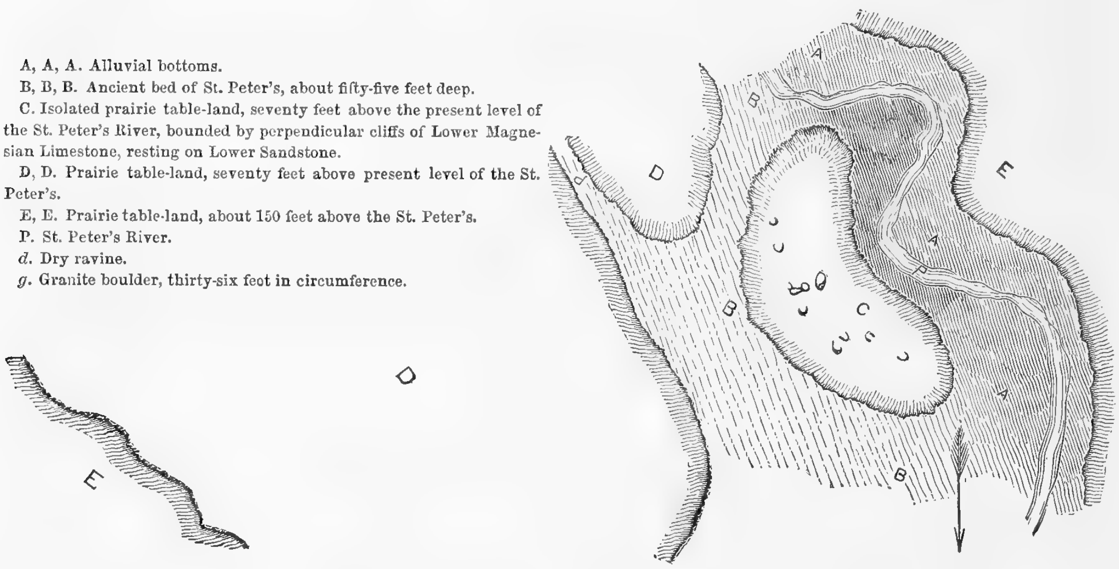
From the summit of the bluff a singular view is presented. A nearly level plain, about a mile in width, is seen extending for several miles in a direction nearly parallel with the river. This plain is bounded on the east by a beautiful terrace of table land, about eighty feet high, from which stretches a fine undulating prairie towards the interior. Rising from the surface of the lower plain, large masses of magnesian limestone and immense numbers of boulders of granite and trap can be seen in all directions. The magnesian limestone occurs in isolated masses only, from eight to ten feet high, and from forty to fifty feet in circumference, having at first sight all the appearance of erratic blocks; yet a close inspection shows that in every instance they are composed of horizontal layers, varying from half an inch to several inches in thickness, arranged as in the original stratification; thus proving clearly that they are not transported masses, like the associated igneous and metamorphic boulders, as has been supposed, but are, in fact, the harder portions of the original sedimentary strata, which have resisted the influence of currents and other denuding forces, whilst the softer materials have been swept away by these agencies.

Two miles above White Earth Bluff, on the left bank of the river, is a hill two hundred and fifty feet high, at the base of which twenty-five feet of sandstone (F. 1) is exposed. The remaining portion of the hill is covered with soil and densely wooded. Two miles further, the same rock is again exposed, in thick beds, on the opposite bank of the river, where its thickness is forty feet. Three miles higher, magnesian limestone (F. 2) projects at intervals from the base to the top of a hill, seventy feet high, presenting an abrupt slope towards the river. Near the summit of the hill the rock is in nearly horizontal layers, but towards the foot it is in detached masses, without any appearance of regular bedding, so that it is probable these have fallen from above.

Four to five miles above this place, and by the course of the river, about twenty miles above Traverse des Sioux, a good section of sandstone, capped with magnesian limestone, is exposed on the east bank of the river, forming a perpendicular escarpment seventy feet high. The sandstone extends to the height of fifty feet, and supports twenty feet of magnesian limestone.

On the table land above the bluff we observed a great many large boulders, some of them angular and others rounded; one of these blocks, consisting of a fine-grained variety of granite, measured thirty-five feet in circumference, and projected more than seven feet above the prairie-level. Here an ancient channel of the St. Peter's, half a mile from the present one, was measured, and found to be seven hundred and

sixty feet wide; its length nearly two miles; both extremities converging towards the present channel. Its sides consist of perpendicular ledges of sandstone, surmounted by magnesian limestone, sixty feet high on the east, and forty-five feet on the west. The bottom is perfectly level, and supports a rank growth of tall grass, presenting the appearance of a luxuriant meadow. Near the centre are two lakes, of nearly an elliptical form, connected by a short and narrow stream. The height of the ancient channel above the present bed of the Minnesota, was ascertained to be twenty feet. The following wood-cut exhibits the topography of this curious region.



A, A, A. Alluvial bottoms.
B, B, B. Ancient bed of St. Peter's, about fifty-five feet deep.
C. Isolated prairie table-land, seventy feet above the present level of the St. Peter's River, bounded by perpendicular cliffs of Lower Magnesian Limestone, resting on Lower Sandstone.
D, D. Prairie table-land, seventy feet above present level of the St. Peter's.
E, E. Prairie table-land, about 150 feet above the St. Peter's.
P. St. Peter's River.
d. Dry ravine.
g. Granite boulder, thirty-six feet in circumference.

To explain how the channel, B, became forsaken, we conjecture that the St. Peter's once divided its waters around the isolated table-land, C, which was then an island; that the portion of the river flowing in the present bed was the first to wear through the limestone down to the underlying soft sandstone, which, from its softness, was worn away faster, and soon drained all the waters from the channel, B.

At the upper end of the gorge, B, a strip of woods crosses its entrance, about one hundred yards wide, while at the lower end the timber extends some distance into the old channel. The trees are mostly large, many of them measuring four feet in diameter.

A mile and a half further up the river, the sandstone and magnesian limestone again protrude, with the same lithological appearance. The height of the sandstone above the water-level is thirty feet; the magnesian limestone eight feet.

Three miles and a half above this place is the highest exposure of these rocks observed on the Minnesota. An unbroken perpendicular escarpment rises to the height of one hundred and fifteen feet above the bed of the river. The different beds occur in the ascending order as follows:

	Feet.	Inches.
White and brown sandstone, similar in character to that found at White Earth Bluff,	70	
Seam of green siliceous marl,		6
Magnesian limestone, containing Lingula and Orbicula,	45	

From these measurements it appears that there is a rise of about forty feet in the strata between the last exposure and this point.

The Blue Earth or Mankato River joins the Minnesota a few hundred yards above this bluff. Our instructions required us to explore this stream and its principal tributaries previous to completing our observations on the Minnesota. We accordingly began the ascent.

Half a mile above the mouth, the sandstone, with a capping of Magnesian Limestone, appears, forming abrupt cliffs, seventy-two feet high. About one mile above the mouth, the same rocks again occur, in solid ledges, with an elevation of forty to fifty feet.

About three miles above this locality is the confluence of Lesueur River, which we entered. About half a mile up this stream, an exposure of Lower Sandstone, F. 1, rises to the height of twenty-five feet above the level of the stream, surmounted by sixty-eight feet of sand, pebbles, and small boulders, the latter not exhibiting any appearance of stratification.

A mile further is a similar section, as follows:*

	Feet.
1. White and brown sandstone,	50
2. Thin beds of loosely cemented conglomerate.	
3. Sandstone,	5
4. Thin bed of firmly cemented conglomerate.	
5. Ferruginous sandstone,	8
6. Nodules of oxide of iron, and argillaceous iron ore,	2
7. Unstratified drift, with large boulders,	18

The nodules of iron ore have mostly a concentric structure, and appear to be of good quality. The superficial indications render it probable that this bed of iron ore may be both extensive and easily accessible.

Two or three miles above the mouth, the hills are composed mostly of sand, gravel, and erratics, resting on a thin bed of light, bluish-gray, arenaceous, stratified marl.

The Psah River comes in on the left side, about five miles above the mouth of the Lesueur River, which, being the larger stream of the two, we turned into it. We had not proceeded far, however, before the water became shallow, and our progress difficult. We succeeded, however, in ascending it some seven or eight miles, by dint of laborious poling and frequent wading, in very rapid water amongst the numerous boulders, but with considerable risk to our craft. At length we reached a region where no rocks could be discovered, even in the lowest cuts of the stream; and where the whole hills seemed to be composed of confused masses

* The beds are always given in the sections in the ascending order, No. 1 being the lowest.

of erratics, sand, and gravel, usually without any distinct bedding, resting on stratified ash-coloured and yellowish arenaceous marl. Even where the hills ranged from one to two hundred and fifty feet in height, no ledges of rock could be discovered.

This being the boundary between the outcrop of rocks of Lower Silurian date and the region of drift, such as Dr. Owen encountered towards the heads of the Iowa and Des Moines Rivers, we proceeded no farther up the valley of this stream. It is worthy of note that we here first observed specimens of a kind of coaly lignite, which will be mentioned more particularly hereafter; these only occurred, however, in loose fragments, swept out by the current of the river from the adjacent drift deposits.

We now proceeded to examine the Blue Earth River. The first good exposure of rocks is at the celebrated Blue Earth Bluff, mentioned by Featherstonhaugh and other explorers. It is composed of sandstone, F. 1, at the base, capped with magnesian limestone, F. 2, with about two feet of thin layers of greenish, blue, and yellow marl, interstratified at the junction of the two formations. This earth the Indians collect, and esteem it highly as a paint. Its appearance and composition is similar to that of the green earth under the fucoidal layers of F. 1, at Marine Mills, which Dr. Owen found derived its colour chiefly from silicate of iron. On the Blue Earth River, it occupies rather a higher stratigraphical position than on the St. Croix, being at the very top of F. 1.* The section of the different beds at this locality is as follows:

	Feet.
1. White and brown sandstone, F. 1, ...	50 to 60
2. Blue, green, and yellow marl, ...	2
3. Magnesian limestone, F. 2, ...	35
4. Erratics and nodules of iron ore, ...	2
5. Other drift deposits, ...	86

The magnesian limestone contains here a Lingula, like that obtained at White Rock. About half a mile above this section is the last exposure of magnesian limestone, witnessed on the Blue Earth. Here the sandstone, F. 1, is sixty feet thick; the magnesian limestone (F. 2), fifteen feet. The sandstone continues to be visible some miles further south. One mile above the Blue Earth Bluff, it is exposed, seventy feet above the river; five miles above, sixty feet, and continues for about a mile, when it gradually decreases in elevation, and finally disappears altogether, about a mile above the mouth of the Watonwan. The only organic remains found in F. 1 in this region of country were imperfect specimens of *Euomphalus Minnesotensis*, obtained at a locality four miles below the mouth of the Watonwan.†

Where the rocks of Lower Silurian date are finally lost beneath the drift, the height of the table-land is one hundred and fifty feet.

* A deposit of similar character, but too sandy to be employed as a pigment, was observed also at the White Earth Bluff on the St. Peter's.

† On the Blue Earth and Psah Rivers, some fine Unios of the following species were noticed. *U. rectus, crassus, fragilis, tenuissimus, bullatus, plicatus, trigonus, alatus, siliquoides, parvus.* Also *Anodonta plana, imbeciles; Alasmodonta truncata, ambigua, rugosa* and *complanata; Paludina decisa; Physa heterostropha*, and *Lymnea megasoma.*

At some points the drift deposits were in stratified beds, and there two layers could be detected containing fresh-water and land shells, separated from each other by about six feet of sand and gravel; but more frequently the different members were blended together, and then no shells could be discovered.

We were never able to discover any fossils in the ash-coloured clay, No. 1, of the following section of the drift formation, as it presented itself high up on the Blue Earth River.

	Feet.	Inches.
1. Ash-coloured clay, ...	8	
2. Coarse sand with some pebbles, ...	2	
3. Ash-coloured clay marl,*	7	
4. Sand and pebbles, with small boulders at base, . .	8	
5. Sand, with fresh-water shells, ...		6
6. Sand and gravel, ...	6	
7. Sand, with fresh-water shells, ...		8
8. Soil and subsoil, ...	6	

The lithological characters of both beds of clay, Nos. 1 and 3, are the same.

Here, as on the Psah River, pieces of lignite are occasionally found disseminated in bed No. 4, but never any regular bed of this mineral. Some of it has the appearance of lignite or carbonized wood, some of inferior cannel coal. The reports of the existence of an important coal basin in this vicinity have, I believe, no better foundation than the existence of transported pieces of this coaly substance in the drift formation found at the head of the southern tributaries of the St. Peter's. These pieces may either have been derived partly from the denudation of some of the northern seams of coal of the Iowa coal-field, or of the lignite formation lying to the west, which Mr. Evans traced high up on the Missouri, and which probably extends some distance east of that river.

The species of fresh-water shells found in bed No. 5, are such as occur in the neighbouring streams and lakes, viz.: *Planorbis parvus* and *bicarinatus*, *Paludina decisa*, *Lymnea columella*, *Physa heterostropha*, (?) *Unio siliquoides*, *Melania Virginica*, (?) and an undetermined species of *Cyclas*.

Bed No. 7 contains both fresh-water and land shells similar to those found in the white shell marl, near the Falls of St. Anthony. The principal species are: *Valvata tricarinata*, *Helix striatella*, *H. alternata*, *H. arborea*, *Planorbis parvus*, and *Planorbis bicarinatus*, *Paludina limosa*, *Lymnea columella*, and undetermined species of *Ancylas* and *Cyclas*.

* The analysis which I made of the ash-coloured clay yielded as follows:

Carbonate of lime, ...	14·2
" magnesia, ...	6·0
Insoluble matter, ...	65·
Alumina, oxide of iron, and manganese, ...	4·4
Water, ...	9·2
Loss, ...	1·2
	100·0

The soil on the top is a dark vegetable mould.

Amongst the drift we found a few erratic specimens of fawn-coloured magnesian limestone, resembling specimens which Dr. Owen brought from Red River of the North, and containing the same Lower Silurian fossils, *Leptæna alternata*, which characterizes particularly the shell-beds, F. 3, A.

Everywhere near the surface, and scattered on the slopes and in the beds of these streams, near their sources, are large erratics, even on the high prairie, and these seem to increase in size and number the nearer you approach the summit-levels of the country.

On the St. Peter's River, seven miles above its confluence with these streams, above described, sandstones of F. 1 are exposed with a thickness of fifty feet. The grain of the rock is rather coarser and its texture more compact than heretofore observed on this stream.*

Commencing at Traverse des Sioux, and extending some ten miles up the river, is one of those undulating prairies which contribute so much to the beauty of this part of the Minnesota country. The fertility of the soil and the background of forest will undoubtedly make this, at no very distant day, a desirable locality for settlers seeking a new country. The woodland abounds in linden, white and sugar maple, aspen, elm, butternut, and hickory, with an undergrowth of prickly ash, gooseberry, and grape-vines.

Thirty-two miles above the mouth of the Mankato, is the White Earth Bluff, which is about seventy feet high, and situated on the left bank. There are no ledges of rock to be seen at this place, but merely deposits of siliceous earthy material, of red colour, from the presence of oxide of iron and loose fragments of brown and red sandstone disseminated.

Two miles below the mouth of the Waraju, sandstone, F. 1, is capped with twenty-five feet of gray concretionary limestone,† with crystals of calcareous spar disseminated.

The analysis of this rock, given below, indicated a much larger per cent. of carbonate of lime than is usual in the calcareous rocks of this part of Minnesota, which are usually highly magnesian; this bed may therefore be of some considerable economical value for obtaining good lime, by burning it. Large masses of the rock have fallen from above, and are easily accessible.

Near the confluence of the Waraju, three benches or terraces of prairie-land are distinctly observed, as indeed at many other points on the St. Peter's. The first, or recent alluvial bottoms, elevated five to ten feet above the water; the second, a level tract of prairie, thirty to forty feet higher, which spreads out to the width of

* In a marsh near by, I found very large and perfect specimens of *Lymnea jugularis* and *Planorbis trivolvus;* some specimens of the latter measured upwards of an inch in diameter.

† An analysis of the concretionary limestone yielded:

Carbonate of lime,	90·
" " magnesia,	00·6
Insoluble matter,	4·4
Alumina, oxide of iron, and manganese,	3·4
Water,	0·6
Loss,	1·0
	100·0

nearly two miles; the third, the upland prairie, which has a further elevation of forty to sixty feet, and in some places is still higher.

At some points on the St. Peter's, in place of the first alluvial terrace, the prairie ascends gradually from near the water's edge to the distance of some six hundred yards, with hardly the least irregularity in the slope; a portion of it, sparingly timbered with small oaks, resembling at a distance a flourishing orchard. These spots appear so like cultivated farms, that when, as is sometimes the case, a cliff of rock can be discerned in the distance, partially concealed by the trees in the foreground, the traveller almost fancies he has discovered the residence of the proprietor. The second bench of land is sometimes strewn with erratics and shapeless blocks of indurated sandstone, derived from some of the neighbouring cliffs.

Nearly opposite the mouth of the Waraju, is an exposure of altered sandstones and conglomerate, dipping towards the north at angles varying from 15° to 30°. The whole height of the inclined strata is one hundred and ten feet. At the base are layers of compact sandstone, of a brick-red colour, which split readily into laminæ of variable thickness. Some of these laminæ are ripple-marked, and resemble specimens brought from near the head of the Menomonie River.* Their thickness is fifteen feet. Reposing on these are metamorphic sandstones of various degrees of induration and colour. Some portions are soft and friable, and, in lithological appearance, do not differ materially from the beds of F. 1, observed in other parts of the valley of the St. Peter's, while other portions are completely metamorphosed into an exceedingly compact quartzite, of a brick or mahogany-red colour. Towards the summit of the ledge are numerous "pot-holes," the sides and bottoms of which were worn smooth, and even polished. The largest of these was found to measure two feet and a half in depth, by two feet in diameter. The bearing of the strata runs nearly east and west.

About one mile in a straight line above the mouth of the Waraju, and three by the course of the river, we found some outliers of coarse conglomerate and granite, a short distance from the bank of the stream. The conglomerate is composed mainly of quartz pebbles and boulders, some of the latter ten inches in diameter; the whole cemented with a siliceous material. Its elevation above the level of the prairie is about ten feet. The course of the exposure is nearly east and west, with a dip towards the south of 20°. The granite is a hundred yards removed from the conglomerate, with its line of elevation running nearly parallel with the latter. Flesh-coloured felspar forms nearly two-thirds of the granite.

The rocks do not appear again *in situ* until we reached La Petite Roché, which is estimated to be about twenty-five miles above the mouth of the Waraju River. Here, again, granite occurs mixed with syenite, elevated between seventy-five and a hundred feet above the level of the river. The granite is highly crystalline, and is traversed by numerous cleavage-planes, which cause it to separate with readiness into angular blocks and slabs. The mineral hornblende constitutes at least four-fifths of the syenite; felspar predominates in the granite.

Half a mile above La Petite Roché, a mass of granite occurs in the middle of the

* A thin seam of red pipestone runs between some of the layers.

river. Its height is about ten feet. On the prairie, a short distance beyond, are other outliers of the same rock. Two miles further on it appears again, and it occurs frequently at intervals of a few miles, to the mouth of the Red Wood River.

Two or three miles below the mouth of this river is one of the most interesting exposures of granite, on the left bank of the river. It rises in irregular, smooth knobs to the height of a hundred and twenty-five feet. At an elevation of forty to fifty feet above the present channel, an ancient bed of the river is distinctly recognisable. The bottom of the bed, as well as the sides, to the height of eight or ten feet, are worn into polished grooves, five to twelve inches deep; there are besides smoothly worn pot-holes, not only in the former bed, but also at various heights, even to the top of the rock, and most of the granite surface is rounded and almost polished; all giving evidence of having been laved for a very long period of time, by a swift current, and corroborating the conclusions heretofore drawn, from the existence of level terraces of alluvial land far above the present highest water-mark, and from the position of strata containing fresh-water shells in elevated positions, that the St. Peter's once flowed at a higher level, or rather, that the land has been elevated at a very recent period of time.

The Bois Rouge, or Red Wood River, as it is termed by Nicollet, is a small creek, only five or six yards wide, with only a few inches of water, and unfit even for canoe navigation.

It was fortunate that by this time the main objects of the expedition up the St. Peter's had been accomplished, since I was attacked, at this stage of my investigations, with a severe acute pleurisy, from which I did not recover for several months, and which in all probability would have carried me off, but for the kind exertions of my friends in camp, and the hospitality and nursing care of Mr. Hopkins and family at Traverse des Sioux, and Captain Eastman and family at Fort Snelling.

In conclusion, I may here review, cursorily, the most important facts ascertained in performing this part of my duty.

With the exception of the Bois Franc District, the whole country may be considered as prairie, the streams only being skirted with wood. On the whole, there is a want of timber for ordinary farming purposes in a thickly inhabited district; but if the growth of timber be encouraged, as the population gradually increases, a deficiency may never be experienced.

Throughout the greater part of the St. Peter's country the traveller is surprised and charmed with the ever-changing variety and beauty of the scenery.

The alluvial land bordering upon the river varies in width from a quarter of a mile to a mile or more. The greater portion of this constitutes numerous natural meadows, covered annually with a luxuriant growth of grass. A small proportion of these alluvial lands is well timbered with ash, elm, sugar and white maple, butternut, white walnut, lime, linden, box-elder, cotton-wood, and hickory. A considerable portion of these flats, being subject to annual overflow, are wet and marshy; in their vicinity, at least in the early settlement of the country, intermittents may be expected to prevail in the autumnal months.

A remarkable feature of this country consists in the small lakes and ponds scattered over it. Many of these are beautiful sheets of water, having the appearance

of artificial basins, which greatly enhance the beauty of the country, especially when skirted, as they sometimes are, by groves of trees, and frequented by a variety of water-fowl, which tend to animate and relieve the otherwise almost deathlike silence which so often pervades the prairie.

For about fifty miles above its confluence with the Mississippi, the St. Peter's has a sluggish current, and is slightly turbid,—hence the Dakota name of *Minnesotah.*

For several months in each year there is sufficient depth of water for steamboats of small draught to ascend as far as the Little Rapids, usually estimated by the voyageurs to be fifty-six miles above the mouth. This impediment could probably be overcome by a single lock of five to six feet. The present keel-boats of the Fur Company are (excepting during high water) unloaded again at this point, and reloaded again above the rapids, after which they meet with no further obstruction for a distance of sixty miles, to Traverse des Sioux, which is as far as the St. Peter's is used for the transportation of freight. Beyond this point the goods for the Indian trade are conveyed in carts.

There is abundant evidence of the rise of land throughout the valley of the St. Peter's; and I would call attention to the fact that the ancient elevated bed abounds in boulders, while but few are seen in the upland prairie, and none on the recent alluvial deposits. Hence I infer that the second bench was not formed by the same causes which accumulated the first bench.

I would observe here that many of the water-courses represented on Nicollet's Map as rivers, are really very small streams, with not sufficient water to render them suitable even for canoe navigation; they are in fact mere creeks or rivulets.

On the St. Peter's River and its tributaries, the Lower Sandstone, F. 1, and Lower Magnesian Limestone, F. 2, are the prevailing rocks for a distance of two hundred and seventy to two hundred and eighty miles southwest of the Mississippi.

The last exposure of the Lower Magnesian Limestone on the St. Peter's is about half a mile above the mouth of the Mankato, or Blue Earth River, where it has only a thickness of twenty-seven feet. The underlying sandstone is still seen extending some thirty miles beyond, viz., nearly to the mouth of the Waraju River; but one mile higher up, there are altered red sandstones, quartzite, and conglomerate, which can be traced to the first exposure of granitic rocks on the St. Peter's.

These are no doubt the lower beds of F. 1, more or less changed in their appearance by metamorphism where they abut upon the igneous rocks, some of the beds assuming the character of a close-grained, compact sandstone, and quartzite, varying from a light to a deep brick-red colour, in fact, presenting the usual lithological character of the beds associated with the red pipestones, so highly esteemed by the Indians, and found in the same geological position in other parts of the District. The last exposure of the magnesian limestone on the Mankato, is about six miles south of the St. Peter's, where it is sixteen feet thick.

The underlying sandstone can be traced six miles beyond, in a southerly direction, to one mile above the mouth of the Wantonwan River, where it is seen just above the water's edge.

On the Lesueur River, the magnesian limestone is not visible, but the sandstone extends about two miles above its mouth, where it is sixty feet thick. On these streams, F. 1 and F. 2 are lost to view under extensive drift deposits, which occupy a great area at the heads of these streams, beyond the limits of the District. No crystalline rocks or metamorphic beds were observed on these rivers.

The table-land, which varies in height from one hundred to two hundred feet, is principally composed of an arable soil resting on drift.

F. 1 and F. 2 of the St. Peter's and its tributaries retain much the same lithological characters which they possess on the Mississippi, many of the individual members being diminished in thickness, and even entirely wanting. None of the beds of either formation, in this part of the Chippewa Land District, have the appearance of being productive either in lead or copper. Section No. 4, S, on Pl. 3, N, gives a connected section of the formations on the St. Peter's, from its mouth to the granite uplift at Red Wood River.

CHAPTER II.

LOCAL SECTIONS ON THE UPPER MISSISSIPPI.

a. Above the Mouth of the Wisconsin.—For the purpose both of investigating the mineral contents of the Lower Magnesian Limestone and Lower Sandstone of Wisconsin, Iowa, and Minnesota, and at the same time tracing out the elements of stratification of these formations, and their palæontological details, I was instructed to make minute local sections, at various points in the Valley of the Mississippi, the results of which are contained in this chapter.

My observations commence at the Falls of St. Anthony, where F. 2, c, forms the base of the sections capped with the shell-beds of F. 3, A.

On the east side, the different members of that formation occur in the following order, above the white sandstone.

	Feet.
1. Grayish buff-coloured layers of Magnesian limestone, containing numerous casts of *Leptæna, Terebratula, Orthis, Spirifer, Orthoceratites, Pleurotomaria,* &c., ...	6
2. Ash-coloured argillaceous limestones, in thin layers, containing but few fossils, ...	5
3. Highly fossiliferous shell limestone, of a bluish-gray colour, . .	23

From three to four feet of the upper beds of the section are above the top of the cascade. The whole height of the perpendicular fall is sixteen feet.

Many of the organic remains of the upper bed are identical with the Trenton limestone, Utica slate, and Hudson River group of the New York system, and their western equivalent, the blue limestone of the Ohio Valley.

The most characteristic species in these beds are *Leptæna alternata, L. planumbona, L. sericea, Orthis testudinaria, O. tricenaria, O. disparilis, Terebratula modesta, Atrypa capax, Bellerophon bilobatus, Pleurotomaria lenticularis, P. subconica, P. umbilicata, Orthoceratite* (species undetermined), *Calymene senaria, Isotelus gigas, Lichas trentonensis(?), Ceraurus pleurexanthemus, Chætetes lycoperdon.*

About a quarter of a mile below the cascade, the lower beds of the shell limestone are better exhibited than at the last section, and they rest here on the white sandstone (F. 2, c). The section is as follows:

		Feet.
1.	Soft, crumbling, white quartzose sandstone, in heavy beds,	20
2.	Ash-coloured, argillaceous schistose limestone, with thin marly seams,	5
3.	Highly fossiliferous shell limestone, of a grayish-blue colour,	13

Both at the Falls of St. Anthony and this place, the fossiliferous beds are surmounted by from eleven to twelve feet of drift material, consisting of sand, gravel, and small boulders, on which rests a bed containing *Lymnea, Cyclas, Physa,* and *Planorbis,* in great quantities. This I traced for the distance of nearly half a mile on the same level, below the falls. On the trail which leads to St. Paul's, about half a mile from the falls, and elevated from forty to fifty feet above the last-mentioned deposit, I observed a white marl, highly charged with *Lymnea, Cyclas, Planorbis, Valvata tricarinata,* and other genera of lacustrine and fluviatile shells, such as now live in the neighbouring lakes and streams.* At Fort Snelling, the sandtone is one hundred and fourteen feet thick; it is here of a pure white colour, composed of loosely cemented grains of quartz.

Above this, we have twenty-two feet of fossiliferous limestone, with numerous organic remains, similar to those at the Falls of St. Anthony. The fossils of the upper beds are mostly casts, but the moulds often show the structure of the original surface. Many of the fossils have a coating of sulphuret of iron, which gives them a bright metallic appearance.

The best section of these rocks that we have observed in Minnesota is at a bluff half a mile below Fort Snelling. The section here is as follows:

		Feet.
1.	White sandstone, without fossils, in thick beds,	92
2.	Soft argillaceous marlite, of a blue colour, in which no fossils were discovered,	5
3.	Ash-coloured limestone, clouded with blue, full of fossils. The most common are *Orthis testudinaria, O. tricenaria, Leptæna sericea, L. deltoidea, L. planumbona, L. alternata, Terebratula modesta, A. capax, Calymene senaria, Phacops callicephalus, Ceraurus pleurexanthemus, Isotelus gigas.* We have also found in this bed portions of an Orthoceras, which must have been from two to three feet in length. It has likewise yielded somewhat abundantly a neat little species of *Cytherina,* exhibiting a punctate surface, besides several species of *Graptolites.* These layers effervesce freely with acids, and contain nearly sixty-five per cent. of carbonate of lime; they will probably afford the best rock for burning into lime of any of the beds in the neighbourhood.† Thickness,	15

* See Sect. No. 2, S.

† The composition of this rock is as follows:

Carbonate of lime,	64·85
" " magnesia,	13·75
Insoluble matter,	12·40
Alumina, oxide of iron, and manganese,	7·50
Water,	1·25
Loss,	0·25
	100·00

	Feet.
4. Ash-coloured, argillaceous, hydraulic limestone, in thin layers, sometimes with a conchoidal fracture. It effervesces slightly with acids, and disintegrates rapidly when exposed to the weather.* No fossils were observed in it. Thickness, ...	5
5. Grayish, buff-coloured, highly magnesian limestone, with numerous casts of fossils, of which the most characteristic are *Pleurotomaria umbilicata, P. subconica, Murchisonia tricarinata, Cyrtoceras macrostomum, Trocholites ammonius, Leptæna deltoidea, Illænus ovatus,* and several species of *Orthoceratites.*	

Three miles below Fort Snelling, on the right bank, the white sandstone is at an elevation of sixty-eight feet above the water-level of the Mississippi, and supports twelve feet of fossiliferous limestone. From one to two miles below this place, twenty-nine feet of sandstone is exposed, with a capping of eleven feet of fossiliferous limestone; and a quarter of a mile still lower down, it has an elevation of only twenty-four feet, with a capping of eleven feet of limestone. Between the last two points, at the junction of the sandstone and limestone, is the remarkable accumulation of trappose and granitic boulders, mentioned in Dr. Owen's Report.

About half a mile above St. Paul's, near the entrance of a small cave, the sandstone has an elevation of only fourteen feet above the river-level, and on it rests eleven feet of shell limestone.

At St. Paul's, the strata again rise; here the cliffs are from seventy to eighty feet high, of which the lower sixty-five feet consists of white sandstone, the remainder being shell-limestone.

About one mile below this point the hills recede from the river. At Red Rock, they are half a mile back, and have an elevation of eighty feet, and can be seen running parallel with the river, and at about the same distance removed from it, for about two miles.

Immediately on the river, at Red Rock, the Lower Magnesian Limestone occurs in thin layers, some of which have an oolitic structure.

This is the first place at which this formation was observed to occur in our descent of the Upper Mississippi.

The soil on the plain between the river and the bluffs is a rich dark vegetable mould.† The same formation continues for about one mile below Red Rock, with

* The following is the composition of this rock:

Carbonate of lime, ...	42·60
" " magnesia, ...	28·46
Insoluble matter, ...	14·16
Alumina, oxide of iron, and manganese, ...	7·83
Water, ...	5·33
Loss, ...	1·60
	100·00

† An analysis of one hundred grains of a rich black soil from Red Rock resulted as follows:

Passed through the fine sieve, ...	55 parts in 100.
Moisture, ...	5·10
Soluble organic matter, ...	8·80
Insoluble organic matter, ...	5·80

a height of from eight to fifteen feet. The strata present an undulated appearance along the course of this exposure, the result probably of lateral pressure. About one mile above Gray Cloud Island, on the left bank of the river, the Lower Magnesian Limestone again appears, and one of the layers, five feet above the water-level, is densely crowded with fossil univalves, closely allied to the genus *Ophileta* of the Calciferous Sandrock of the New York system. The fossils were all casts, and none of them could be procured in a well-preserved condition. These beds form continuous escarpments to Gray Cloud Island, with an elevation varying from ten to fifty feet. At Gray Cloud Island, the uppermost layers are quarried for burning into lime. They are highly magnesian, containing, according to Dr. Norwood's analysis, 40·7 per cent. of the carbonate of that earth, and do not make as good lime as that obtained by burning the fossiliferous limestone at the mouth of the St. Peter's, and bed No. 3 of the section at the Falls of St. Anthony.

After passing this exposure, no more rocks are to be seen on the Mississippi for the distance of about ten miles. The river bottoms are well timbered with oak, maple, elm, and basswood. A short distance back from the river, the land is rolling prairie, and the soil is usually good and well adapted for cultivation.

About three miles above the mouth of Lake St. Croix, on the north bank of the river, is a bluff two hundred and five feet high. It consists, at the base, of the Lower Sandstone, F. 1, *f*, which has a thickness of thirty feet; on this is superimposed the Lower Magnesian Limestone, F. 2, with a thickness of a hundred and seventy-five feet. This locality is the most northerly point on the Mississippi, where the Lower Sandstone is seen above the waters of that stream.

Two miles above the mouth of the St. Croix, the Lower Magnesian Limestone rises to the height of two hundred and thirty feet above the bed of the Mississippi. Near the water-level, the strata contain *Ophileta*. After passing this point, no rocks are seen in place for the distance of a mile and a half, after which the Lower Magnesian Limestone again appears, and continues with but little interruption to the confluence of the St. Croix.

Eleven miles below this is "Old Man's Prairie," situated on the east bank of the Mississippi. The Lower Magnesian Limestone is the prevailing rock to this place. It is seen projecting in perpendicular ledges from different portions of the slopes of the bluffs. These bluffs often rise to the height of three hundred and twenty feet above the bed of the Mississippi. The rock exposures usually occur near their summits, while the lower portion of the hills are generally less abrupt, and mostly covered with soil, vegetation, and loose fragments of rock, which have fallen from the strata above, and which conceal the underlying strata. Judging from the character of the slopes, it is highly probable that the Lower Sandstone forms the

Silica,	69·40
Carbonate of lime,	2·00
Alumina by muriatic solution,	1·50
" " sulphuric solution,	2·00
Magnesia,	1·22
Alkalies,	0·18
Peroxide of iron,	3·40

base of the hills. At "Old Man's Prairie," a measurement of the elevation of the bluff gave a height of three hundred and fifty feet, the upper fifty feet consisting of transported gravel, sand, and boulders, below which the Lower Magnesian Limestone is the only rock visible, if we except a seam of sandstone at the base, two and a half inches in thickness. The superior beds are intersected by numerous fissures, which intersect the strata in all directions.

At La Grange Mountain, near the head of Lake Pepin, is an interesting exposure of the Lower Sandstone and Lower Magnesian Limestone. The whole height of the bluff is about three hundred and fifty feet, of which the Lower Magnesian Limestone constitutes one hundred and eighty-five feet. The section at this point is given below:

	Feet.
1. Soft green and yellow sandstone, containing *Lingulas* and *Orbiculas*, .	26
2. Alternations of green and yellow sandstone, and schistose sandstone, with green particles disseminated, ...	5
3. Brown dolomitic layers, containing *Orthis*, *Lingulas*, and columns* of *Crinoideæ*, ...	4
4. Brown, white, and green sandstone, with schistose dolomitic intercalations, ...	26
5. Yellow and ash-coloured argillo-calcareous rock, containing *Dikelocephalus Minnesotensis*, *Lingulas*, and *Orbiculas*, ...	4
6. Alternations of brown and yellow sandstones, surmounted by thick-bedded white and brown sandstone, ...	50
7. Slope covered with soil and vegetation, about	135
8. Lower Magnesian Limestone, F. 2, ...	150
	400

From this locality to one mile below the mouth of the Miniskah River, the Lower Magnesian Limestone appears in perpendicular walls, forming the upper portions of most of the bluffs.

The next good section showing the members at the junction of these two formations, is about two miles below the head of Lake Pepin, and at Maiden's Rock.

At the first of these localities, yellow and green sandstone is seen twenty-five feet above the level of the lake; and extending up the slope are thicker beds of white and brown sandstones, supporting F. 2.

About two hundred feet of a perpendicular escarpment of Lower Magnesian Limestone faces the lake at Maiden's Rock, with a talus beneath of nearly the same height, from which beds of sandstone occasionally appear.

* The presence of the remains of Encrinites, in bed No. 3 of this section, is interesting, since hitherto this family of fossils has never been observed before in this country, so low in the geological formations; the strata in which they occur being in beds equivalent in age to the Potsdam sandstone of New York. The oldest Crinoids that we had any knowledge of previous to this discovery, are described by Hall in the first volume of the "Palæontology of New York," and procured from the Chazy Limestone.

Bed No. 4 contains the same remarkable species of Trilobite, *Dikelocephalus Minnesotensis*, first found in argillo-calcareous beds on the banks of Lake St. Croix. Associated with this species at La Grange Mountain, the cephalothorax and pygidium of another smaller species of Trilobite occurs, which will probably constitute a distinct genus. The same bed contains two species of Lingulas, one of which is probably peculiar to it.

A mile below the mouth of Miniskah River, another Trilobite bed, lower stratigraphically than that of La Grange Mountain, is seen, just above the talus of rubbish and loose rock, at an elevation of one hundred and seventy-three feet above the water.

This Trilobite grit is slightly micaceous, and of a light greenish-gray colour; its thickness is about three feet, and the layers are thinly laminated. Besides several species of Trilobites, it has yielded one small species of *Orthis*, and two species of *Lingulas*. One layer contains those remarkable spines, belonging to a curious species of Trilobite, in the shape of a fish-hook. The most common species is the one we have hitherto designated as the Miniskah Trilobite. A third species also occurs here, much smaller than either of the others, its cephalothorax scarcely exceeding two lines in length.

Over the Trilobite grit are ninety-three feet of sandstone, the lower beds of which are thinly laminated, and of green and yellow colours. The upper are thicker, and have intercalations of magnesian limestone. On this reposes ten feet of ash-coloured argillo-calcareous layers, containing *Dikelocephalus Minnesotensis;* the whole surmounted by soft brown and yellow sandstone, containing *Lingulas*.

The Great Slide, about five miles below the mouth of the Miniskah, shows a very instructive section of many of the members of F. 1.

	Feet.
1. The talus at the foot of the bluff conceals the beds belonging to F. 1, *c*, .	66
2. Green, and soft green sandstones, with scales of mica, . . .	25
3. Brown calcareous rock, ...	4
4. Layers of green sandstone, alternating with green earth, . . .	36
5. Micaceous sandstone with Trilobites, ...	2
6. Alternations of green and ferruginous sandstone, ...	22
7. Micaceous sandstones, with *Dikelocephalus Miniscaensis*, . . .	3
8. Loose green sand, and soft green sandstone, ...	15
9. Thin seam of greenish blue earth.	
10. Laminated green and yellow sandstone, ...	38
11. Concretionary green, red, and yellow sandstone, with silicate of iron disseminated, ...	3
12. Green, red, and yellow compact sandstone, with thin dolomitic layers passing downwards into brown *Orthis*, and encrinital siliceo-calcareous rock, .	44
13. Yellow and ash-coloured argillo-calcareous rock, containing *Dikelocephalus Minnesotensis*, and another species of Trilobite, ...	9
14. Alternations of thin-bedded and light brown and bluish sandstone, .	6
15. Thick beds of soft yellowish sandstone, with hard, botryoidal concretions, passing downwards into light-coloured, fine-grained sandstone, . .	51
16. Mammillary and botryoidal layer of white sandstone banded with yellow,	3 to 4
17. Quartzose sandstone, with intercalations of magnesian limestone, with glistening crystalline facets, ...	85
18. Lower Magnesian Limestone, ...	112
	525

The next locality, "Mountain Island" (*La Montagne qui trempe à l'eau*), exhibits several of the lower beds of F. 1, in connexion with most of the preceding, and is perhaps the best connected section of the stratification of F. 1 to be found on the

Upper Mississippi, as every layer, from near the base of the coarse Lingula grit and Obolus grit, up to the base of the Lower Magnesian Limestone, admits of being traced out as follows:

		Feet.
1.	Coarse Lingula and Obolus grit, especially fossiliferous, towards the top,	104
2.	Green sand and soft green sandstone, with Trilobites,	6
3.	Soft thin-bedded, green, micaceous sandstone,	14
4.	Brown siliceo-calcareous rock,	4
5.	Thin layers of green sandstone, alternating with green earth,	36
6.	Micaceous sandstone with Trilobites. *D. Miniscaensis*,	2
7.	Alternations of green and ferruginous sandstone,	20
8.	Micaceous sandstone, with *D. Miniscaensis*,	2
9.	Loose green sand and soft green sandstone,	15
10.	Green and red sandstone, charged with silicate of iron,	5
11.	Six inches of bluish-green earth.	
12.	Thin-bedded green and yellow sandstone,	35
13.	Band of concretionary red and yellow sandstone, with silicate of iron disseminated,	3
14.	Green, red, and yellow, compact sandstone, with thin dolomitic layers passing downwards into siliceo-calcareous rock,	40
15.	Yellow and ash-coloured argillo-calcareous layers, with *D. Minnesotensis*,	9
16.	Alternations of thin-bedded, light brown, and ash-coloured sandstone,	6
17.	Thick beds of soft yellowish sandstone, &c., as at the Great Slide,	50
18.	Mammillary and botryoidal layers,	2
19.	Quartzose sandstone, with intercalations of magnesian limestone,	80
		433

The top of bed No. 1 is almost made up of Lingulas and Obolus, and five feet above the fossiliferous layers, the gritstone contains the same species of Trilobite that occurs in the third Trilobite bed, but the rock was so friable that it was almost impossible to preserve specimens. The upper and lower divisions of the third Trilobite bed are here separated by twenty feet of green sandstone, alternating with green earth; the species in both members are, however, the same, and there appear to be at least three different species. Associated with them is a nearly circular species of *Orthis*, and a small *Lingula*. The Trilobite beds are mostly easily cleavable gritstones, of a grayish-green colour, until exposed to the weather, when they assume a pale buff hue, and become harder.

Five miles below Mountain Island, a fine-grained, yellow sandstone, charged with *Obolus Appolinus*, contains also a minute species of Trilobite; the head has a thickness of about four feet, and underlies the coarse Lingula grit, numbered 1 in the last section. These strata have a slight dip here to the northwest, and can be traced for a mile down stream; and near the termination of the exposure the forked-tailed Trilobite was observed associated with the above-mentioned fossils, but it is difficult to procure good specimens here, owing to the soft nature of the rock. This latter Trilobite has not been observed in any of the higher Trilobite beds. The *Obolus Appolinus*, which occurs here in great profusion, associated with these Trilobites, has even the nacre preserved with much of its original lustre and colour. These layers also furnished two species of *Lingulas*, one of which, a large oval

species, we have not observed elsewhere; the other appears to be one of the same species found at the Falls of the St. Croix.

Five miles below Bad Axe, and nearly opposite Winnesheik's Village, the elevation of the bluff is one hundred and ninety-two feet above the water-level. The Lower Sandstone, F. 1, has here a thickness of three hundred and forty-two feet, on which reposes a bold cliff of Lower Magnesian Limestone, one hundred and fifty-two feet thick. Towards the top of this latter rock the beds are cherty, and contain *Euomphalus* and other Gasteropoda, as well as imperfect remains of *Orthoceratites.* Here, as elsewhere in the region of F. 2, its cherty beds are the most fossiliferous part of the formation.

From here to Lansing, the bluffs vary in elevation from four hundred to five hundred and fifty feet. The bluff at Lansing measured four hundred and ten feet; the approximate thickness of F. 1 being here two hundred and seventy-five feet, and that of F. 2 one hundred and thirty-five feet, giving a decline of the strata of about seventy feet in three miles.

From this point I proceeded to examine the country situated between the Mississippi and the Upper Iowa, chiefly for the purpose of ascertaining the boundaries of F. 3 in that direction.

Leaving Lansing, we followed the valley of a small creek, in a westerly direction, for the distance of about four miles. This valley is bounded on either side by hills elevated from three hundred and fifty to four hundred feet, covered, in many cases, with high grass, and a tolerably thick growth chiefly of white and black oak, hickory, maple, and poplar. At the base of a number of the hills the Lower Sandstone is found, and towards their summits the Lower Magnesian Limestone, the latter sometimes projecting out in bold, precipitous escarpments.

The soil in the valley is a rich, dark, sandy loam, and that of the slopes but little inferior; even on the ridges, where it has been derived mainly from the decomposition of the Lower Magnesian Limestone, the soil is good, and lies well for farming operations. From the base of the hills issue cool and clear springs, which unite to form small streams, in whose sparkling waters are to be seen an abundance of fine trout. Leaving this valley on our left, we wound round the foot of a high ridge, and proceeding in a northwesterly direction, we began to ascend a ravine, which led to the high table-land, whence we had an extensive view of the surrounding country.

About one mile to the west, a series of oblong mound-like elevations can be seen rising above the general level of the country, similar in appearance to those occurring near Bissel's Farm, in the vicinity of Lake St. Croix. On examination, they proved to be composed of the same formation. At the base, is the white quartzose sandstone of Fort Snelling, surmounted by buff-coloured dolomitic beds containing *Orthis, Murchisonia, Streptoplasma,* and columns of *Crinoidea.* These upper layers occupy the same geological horizon as the buff-coloured strata at Prairie du Chien, and are three hundred and forty feet above the water-level of the Mississippi, and constitute the most inferior beds of the Upper Magnesian Limestone formation of the Northwest.

The height of these mounds is about eighty feet above the general summit-levels of the country, of which sixty-six feet is sandstone. Westwardly they were seen

extending as far as the eye could reach, occupying a width of country from two to three miles in extent.

Leaving these mounds to the left, and proceeding in a northwesterly direction, five miles further brought us to some picturesque exposures of Lower Sandstone and Magnesian Limestone, projecting in rugged escarpments from the sides and summits of the hills, giving to the latter a peculiar castellated appearance. Towards the base of the hills, beds of sandstone were frequently exhibited, in nearly horizontal stratification, separated from each other by intervening spaces covered with a rank growth of coarse grass.

Near by, we struck the Iowa opposite a deserted Winnebago village, and found an old Indian trail leading up the stream. Following this between two and three miles, we ascended the bluffs, which were found to have an elevation of upwards of four hundred feet. They consist of the prevailing rocks of the country,—Lower Sandstone and Magnesian Limestone; the beds of the latter formation being much broken, and traversed by numerous fissures. The superior strata are mixed with much chert, and contain numerous cavities filled with calcareous spar.

Near this vicinity Messrs. Hatfield and Clayton found small quantities of lead ore, and raised about a thousand pounds.

Resuming our route down the Mississippi, I found the bluffs at Cap à Lai, of Sandstone and Lower Magnesian Limestone, four hundred and fifty feet high; and, a short distance below this, on Section 4, of Fractional Township 99 north, we found, near the water's edge, the third Trilobite bed of F. 1, with its characteristic fossils.

Escarpments of Lower Magnesian Limestone, based on sandstone, continue for several miles on the west side of the Mississippi, with an elevation of four hundred to four hundred and fifty feet.

In the southeast corner of Fractional Section 6, of Township 97, the altitude of the bluff is three hundred and forty-five feet. For the first one hundred and eighty feet, ledges of sandstone, F. 1, are partially exposed; over this rests:

	Feet.
1. Thin-bedded magnesian limestone, possessing an oolitic structure, .	13
2. Cherty beds, with concentric markings, ...	1
3. Oolitic magnesian limestone, ...	2
4. Alternations of magnesian limestone and sandstone, ...	6
5. Escarpment of heavy-bedded magnesian limestone, . . .	144

After passing the last exposure, the bluffs recede from the river, being separated from it by a nearly level bench of bottom land, half a mile wide, through Fractional Sections 7 and 18, Township 97, Range 2 west, and 13, 24, and 26, of Township 97, Range 3 west.

At the point known as Painted Rock, situated in the southeast corner of Section 3, Township 96, Range 3 west, the bluff is three hundred and seventy feet above the water-level, and affords a good section of the beds of Lower Magnesian Limestone, resting on about one hundred and forty-five feet of white and yellow sandstone, projecting at intervals from the slope. The oolitic beds are here one hundred

and fifty feet above the water-level, alternating with sandstone, F. 1, *f*, and covered by one hundred and eighty-seven feet of magnesian limestone.

Similar bluffs extend to the mouth of Yellow River, the junction between F. 1 and 2 declining gradually about one hundred feet in a distance of about three miles. At this place the magnesian limestone is traversed, near its summit, by seams of chert, and contains *Euomphalus* and another Gasteropod, which appears to be a species of *Natica*.

About two miles above Prairie du Chien, I found, towards the head of a ravine, the Upper Sandstone, F. 2, C, exposed in heavy beds, with a thickness of fifty-five feet, and still higher up the shell-beds, F. 3, A, containing many of the same species of Mollusca as at St. Anthony. The most characteristic are: *Illænus ovatus, Isotelus gigas,* an undetermined species of *Phacops, Leptæna alternata, L. sericea, Orthis testudinaria, Bellerophon bilobatus, Chætetes lycoperdon, Pleurotomaria lenticularis, Ambonychia undata,* and a *Modiolopsis.*

Not far from Prairie du Chien I found the succession and thickness of the beds, as far as exposed, nearly the same as on Section No. 1, A. For about forty feet above the river, no rocks can be seen. Then we have:

	Feet.
1. An escarpment of one hundred and twenty feet of magnesian limestone, with slope of forty feet, where no rocks are exposed, . . .	160
2. White sandstone, F. 2, C, ...	50 to 60
3. Buff magnesian limestone, with few fossils, chiefly *Orthis* and columns of *Crinoidea*,*	20
4. Beds of shell limestone, about, ...	100

This last bed afforded the following species: *Illænus crassicauda, I. ovatus, Isotelus megistos* (?), *I. gigas, Ceraurus pleurexanthemus, Phacops callicephalus, Pleurotomaria subconica, P. umbilicata, P. lenticularis, Subulites elongata, Murchisonia tricarinata, M. bellicincta, Bellerophon bilobatus, Orthoceras junceum, Cyrtoceras macrostomum, Trocholites ammonius, Orthis testudinaria, O. tricenaria, Leptæna alternata, L. sericea, Terebratula capax, T. modesta, Ambonychia undata,* besides undetermined species of *Avicula, Modiolopsis,* and *Orbicula.*

b. Below the Mouth of the Wisconsin.—I was directed, at the close of the season's operations in 1849, to continue my detailed sections on the Mississippi, below the mouth of the Wisconsin River, as far as its confluence with Red Cedar, for the purpose chiefly of ascertaining whether any limestones of carboniferous date could be detected immediately south and west of the boundary line of the Upper Magnesian Limestone, or adjacent to the limestone of Cedar and Iowa Rivers.

The results of these investigations are here submitted.

As the Upper Magnesian Limestone of the Dubuque and Mineral Point Districts, together with its subordinate shell-beds, have been described in Dr. Owen's Report of 1839, I will merely mention here a few localities where we found some well-defined characteristic fossils, on our descent of the Mississippi. At Cassville, in the shell-beds, F. 3, A, *Leptæna alternata, L. planumbona, Calymene senaria.* Fifteen miles above Dubuque, *Cyrtoceras macrostomum,* and the pygidium of a Tri-

* This bed seems to be absent at the Falls of St. Anthony.

lobite, referable, probably, to *Sphærexochus*, and probably of an undescribed species. Three miles above Savannah, *Orthis occidentalis*, *O. testudinaria*, *Terebratula capax*, *T. modesta*, *Leptæna sericea*, *L. alternata*, *L. deflecta*, *L. planumbona*, and an undetermined species of *Murchisonia*, *Streptoplasma*, *Calymene senaria*, and *Chætetes lycoperdon*. In addition to the above there occur here remains of *Crinoidea*, referable to the family *Cystidea* of Von Buch. The species corresponds with that described in the first volume of the Palæontology of New York, under the name of *Echino-encrinites anatiformis*. The spines of the fossil are tolerably abundant; and in a single specimen, the first series of plates (pelvis) still remain attached.

On approaching Parkhurst, near the boundaries of F. 3, my local sections again commence. Five miles above that place, a low ledge of light buff magnesian limestone is exposed near the water-level of the river. It contains an abundance of casts of columns of *Crinoidea*. The bodies are rare, but we succeeded in obtaining two specimens of this portion of the animal. These approach, in the number and arrangement of plates, to the genus *Eucalypto-crinus*, of Goldfuss.

Two miles further, low ledges of soft, yellowish magnesian limestone appear, and continue to prevail as far as Quarry Creek, which joins the Mississippi a short distance above Parkhurst. Their height varies from six to twelve feet. A few hundred yards above the creek, these strata occur in horizontal beds, elevated five feet above the water-level, where a quarry has been opened; and, a short distance back from the river, is a second quarry, at a higher level, twenty-six feet above the river. The lower layers consist of strata from four inches to a foot in thickness; to these succeed thin laminated layers, from a few lines to several inches in thickness.

On Quarry Creek, half a mile above the mouth, the strata form perpendicular cliffs forty-five feet high. The rock is a soft magnesian limestone,* of a light yellow colour, containing small cavities, lined with crystals of quartz and calcareous spar, and being easily wrought, is extensively used for the construction of buildings at Parkhurst and Le Claire. The beds appear to lie horizontal.

Between Quarry Creek and Parkhurst, a few exposures of the same beds are seen near the water's edge. They dip at considerable angles, but the inclination is not uniform.

Near the lime-kiln at Parkhurst, where the strata have been laid bare sixteen feet above the water-level of the Mississippi, I found a bed filled with casts of polyparia, among which I recognised *Stromatopora polymorpha* (?), and several other forms which I have found in the Upper Silurian strata on Bear Grass Creek, near

* An analysis of an average specimen from this locality yielded the following proportion of constituents:

Carbonate of lime,	52·15
" magnesia,	42·10
Oxide of iron, alumina, &c.,	1·90
Insoluble matter,	1·20
Moisture,	1·55
Loss,	1·10
	100·00

Louisville, and in the glades of Decatur County, Tennessee. The rock is highly magnesian, and assumes a cellular character from the presence of the casts of corals. Higher up the hill, twenty-two feet above the river-level, the rocks are quarried for burning into lime, and though still magnesian, they seem to afford a tolerable lime. They repose on the strata above-mentioned, and contain *Leptæna depressa,* and *Terebratula reticularis* (small variety).

In a small creek about half a mile above Le Claire the rocks have a considerable local dip to the northwest, and the following section is exposed:

	Feet.
1. Thick-bedded magnesian limestone, with casts of *Murchisonia, Pleurotomaria, Favosites Gothlandica,* and *Orthoceratites,* . . .	15
2. Massive magnesian limestone, with *Pentamerus galeatus* (?), casts of *Lituites* and *Lucina, Favosites Gothlandica,* a large *Cyrtoceras* and a small *Orthis,*	20
3. Broken magnesian limestone, made up almost of casts of a small globose *Terebratula.*	
4. Bed containing *Orthis canalis* (?), ...	6
5. Thin layers, without fossils.	
6. Bed containing *Orthis canalis* (?), ...	20
7. Thin shaly layers, without fossils.	

At Le Claire, the rocks are seen a little above the water-level, containing numerous casts of a *Pentamerus* (probably *P. Galeatus*); and *Terebratula Wilsoni* was found in rocks taken from the foundation of a house thirty-five feet above the river.

Two miles below Le Claire, and opposite Smith's Island, the rocks contain *Favosites Gothlandica, Gorgonia,* or *Fenestella,* and casts of columns of *Crinoidea.*

Just below this locality, opposite Smith's Island, the first exposures of sandstones, shales, and argillaceous iron ore of the coal-measures, make their appearance, abutting and even resting immediately on the above magnesian limestone of the Upper Silurian date.* The sandstone which forms the lower part of the section is ash-coloured, with small cavities filled with carbonaceous matter; above this lie the shales, with argillaceous iron interstratified; the latter sometimes in flattened nodules, containing impressions of Lepidodendron. The thickness of these strata is above fifty-five feet. Below this, the magnesian limestones of Upper Silurian date reappear at several points before they are finally lost to view under the waters of the Mississippi; once, a quarter of a mile below the first carboniferous exposure, where they attain a height of six feet above the water-level, and again, a few hundred yards lower down, in perpendicular walls, fifty-eight feet high, with a dip of 26° to the north-northeast. No limestone could be discovered here referable either to the Carboniferous or Devonian systems. Magnesian limestones of Upper Silurian date are again seen about one mile below Smith's Island; thence they gradually decline, and are soon lost to view. Near Hampton, the carboniferous sandstones and shales again

* From Le Claire to this point, the stratified rocks support a deposit of loose sandy loam, imbedding immense numbers of *Unios* and other genera of fluviatile shells, which would afford an excellent mineral manure. This shell loam seems to be of considerable extent, and is usually reached, even some distance back from the river, after penetrating the soil.

appear, and continue for a mile and a half, interrupted occasionally by the last partial uplifts of magnesian limestone.

No true carboniferous limestone was discovered here, but, two miles below Hampton, limestones of the Devonian system crop out in ledges about six feet high. The rock is almost white, of an exceedingly close texture, and effervesces freely with acids. In appearance it resembles the Bird's-eye Limestone of Kentucky; some layers have small crystalline spots, arising from the presence of a serpuliform coral, probably belonging to the genus *Syringopora*, which is shown more distinctly on the weathered surface of many of the slabs. Associated with this fossil, we found some imperfect specimens of *Terebratula* and *Loxonema* (?).

A short distance below this exposure, on the same bank of the river, are numerous boulders, of granite, gneiss, and greenstone porphyry, some of which are several feet in diameter.

About three and a half miles below Hampton, the white compact limestone again reaches the surface, forming a low ledge, elevated only one foot above the water-level.

A few hundred yards further down stream masses of yellow sandstone are strewn along the shore; and a short distance below, an ash-coloured, calcareo, siliceous grit crops out in thin layers, full of *Lepidodendra*, *Calamites*, *Sphenopteris*, and *Pecopteris*, some of them beautifully preserved. The beds were too close to the water's edge to ascertain the relative stratigraphical position of these sandstones and shales.

A quarter of a mile still further down the river, the white limestone is again exhibited, in ledges fifteen feet high, with a dip to the northeast of about 3°. One of the beds, five feet above the water-level, contains a profusion of small *Spirifers*, which appear to be identical with *Spirifer glabra* of Sowerby.

From this point, the white compact limestone is almost constantly exposed, to Davenport, with an elevation varying from eight to fifteen feet, and usually in perpendicular walls. Just before reaching the mouth of Duck Creek, the strata assume a massive character, and exhibit, on the weathered surface, remains of *Cyathophylla* and other genera of Polyparia.

At Davenport, directly on the river, the white limestone appears in a perpendicular wall, ten feet high. Back from the river, at Le Claire's quarry, higher beds have been laid bare. The base of the quarry is forty-four feet above the water-level of the Mississippi, and the white limestone is seen extending to the height of fifty-four feet, ten feet being exposed in the quarry. The lower layers here contain numerous Devonian species of fossils, viz., *Atrypa reticularis*, *A. aspera*, *Chonetes nana*, *Orthis resupinata*, *Astrea ananas*, *A. hexagonum*, *Favosites polymorpha*, *F. spongites*, *Spirifer*, two species, and an undetermined species of *Pentamerus*, together with other forms, characteristic of the shell and coralline beds of the Falls of Ohio, now regarded as equivalent to strata of the Devonian epoch of Europe.

The upper layers of the quarry are highly charged with remains of *Crinoidea*; in fact, some portions of the rock are almost entirely composed of the columns of these animals. It is rare, however, to find the visceral cup. We found here only four specimens of this part of the Crinoid, and these crushed specimens of *Hexacrinus*.

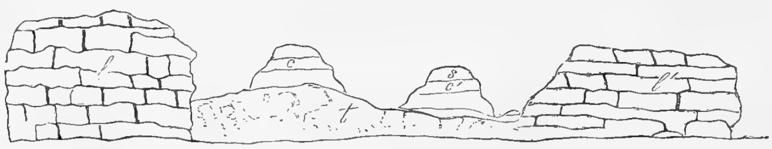
From Davenport to Rockingham the white compact limestone prevails nearly the whole distance, forming sometimes low perpendicular walls, four to ten feet high, and sometimes gradually sloping banks down to the margin of the Mississippi.

The shores are here frequently lined with boulders, some of which are four feet in diameter. The hills rise to the height of one hundred and fifty feet, presenting a gentle inclination, with vegetation extending down to the water-level; so that no rocks are visible except in the above quarry.

It is not until reaching a creek, half a mile below Rockingham, that the rocks can be studied. Here an argillaceous limestone crops out in thin shaly layers, nine feet above the water, disintegrating by exposure. In the debris, many good fossils can be found, of the following species: *Atrypa reticularis, A. aspera, Terebratula concinna, Spirifer euruteines, S. granulifera, S. heteroclites, Orthis resupinata, Leptæna inequistriata* (?), *Chonetes nana, Phacops macrophthalma, Favosites spongites,* and *F. polymorpha.*

At the mouth of the next creek emptying into the Mississippi, along with many of the above species occur, *Olivanites Verneuilii, Phacops crassimarginata, Pleurorhynchus alæformis, Astræa ananas,* and *A. hexagonum.*

About three hundred yards up the first of these creeks is an outcrop of coal, enclosed between ledges of limestone of Devonian date, thus:



l. Devonian limestone, eighteen feet. *c, c'.* Coal, nine feet above creek. *t.* Talus. *s.* Shale. *l'.* Devonian limestone, eleven feet.

The limestone is hardly twenty feet from the coal, and rises, a little below, to the height of twenty-three feet. The coal is two and a half feet thick, and reposes on ash-coloured clay, with dark, thinly-laminated shale over it, six to eight inches thick.

Fifty to sixty yards above this place, there is another coal exposure, occupying a similar fault in this limestone formation. At both localities the limestones contain fossils, the same as those previously enumerated as occurring in the ledges at the mouth of the creek.

The coal is of inferior quality, being much impregnated with pyrites. Outcrops of the same seam of coal have been discovered at several other places in the vicinity.

At New Buffalo, these limestones of the Devonian System are again to be seen, and are exposed for about five miles on the north side of the Mississippi, varying from five to twelve feet in height, the hills back from the river being from seventy to one hundred feet in elevation; and one mile above Pine Creek, coal appears again, twenty inches in thickness, in the following relation to the associate rocks, No. 1 being the lowest.

	Feet.	Inches.
1. Limestone (ferruginous), containing *Atrypa reticularis, A. aspera, Spirifer euruteines,* and other Devonian species, . .	20	
2. Light yellow clay, ...		15
3. Dark, thinly laminated shale, ...	1	
4. Coal, ...		20
5. Coarse and fine sandstone, thickness not seen.		

The coal is of the same quality as that on the creeks above-mentioned.

The hills are here elevated about eighty feet above the river.

A few hundred yards above Pine Creek, these limestones are visible eleven feet thick, and gradually rise to eighteen feet, the dip being about 3° to the southwest, and contain many of the same species of fossils as have been enumerated.

Three miles below the mouth of Pine Creek, the ferruginous bed of limestone has ash-coloured layers above it, containing a *Euomphalus*, and several corals of the same species as are found in the equivalent beds on the Falls of the Ohio. These beds extend for about half a mile along the river, and rise to the height of seventeen feet.

From one to two miles below this last exposure, the sandstones of the coal-measures appear in mural cliffs, on the right bank, containing *Lepidodendra*, *Calamites*, and *Sigillaria*, and under these, argillaceous shales can be perceived; above, there are thinly laminated shaly layers. At the upper end of the exposure the sandstones are twenty feet in height, gradually increasing in elevation down stream; they finally reach ninety feet above the water-level, the hills being about one hundred and thirty feet.

It was not until we reached the vicinity of the mouth of the Iowa, that we discovered any carboniferous limestone. This seems, as far as we have been able to ascertain, the highest point on the Mississippi where limestones of this age can be traced.

CHAPTER III.

LOCAL SECTIONS ON THE WISCONSIN AND BARRABOO RIVERS.

Wisconsin River.—As detailed descriptions have elsewhere been given of the various beds composing the bluffs in the immediate vicinity of the mouth of the Wisconsin River, I commence this part of my Report with an exposition of the stratigraphical details four miles above the mouth. At this point the hills have an elevation of four hundred feet, the Lower Magnesian Limestone, F. 2, is in place near the water's edge, and two miles further up on the south side is a good section. The different members, with their relative thickness, occur as follows:

	Feet.
1. Base, concealed by vegetation, but probably occupied entirely by Magnesian Limestone, F. 2, ...	160
2. Lower Magnesian Limestone, exposed in a perpendicular cliff, the upper beds cherty, and containing *Ophileta* (?) and *Euomphalus*, . .	40
3. Yellow quartzose sandstone, similar in texture and grain to the equivalent bed at the mouth of the St. Peter's, but not so white, . .	126
4. Buff calcareous rock, partially exposed, ...	34

Near the base of No. 3, the rock is composed of angular grains of quartz, loosely cemented, and some layers are ripple-marked; near its junction with No. 4, it is made up of rounded grains, and some beds possess almost an oolitic structure. No. 4 contains some organic remains, but not in a good state of preservation.

Beyond the Ferry House, only ledges of Lower Magnesian Limestone can be seen projecting at intervals on the slope. Loose slabs of sandstone are, however, found near the water's edge.

For two miles above the last section, the strata rise rapidly, so that the Lower Sandstone, F. 1, already forms at this point eighty feet of the base of the hills, the lower beds being thick, compact, and fine-grained; the upper, coarser and thinner-bedded. For about one hundred feet, there are intercalations of magnesian limestone, with the sandstone, F. 1, *f*, the layers varying from an inch to a foot in thickness, and divided by vertical cracks; towards the top they assume an oolitic

structure, as has frequently been observed in the corresponding beds in the Mississippi sections. No rocks are exposed here in the hills above these beds of passage between F. 1 and F. 2.

Between the Upper and Lower Ferry, the hills on the south have a greater elevation than those on the north side of the river. From the wooded slopes of the former only occasional outcrops of rocks are visible.

At the second ferry, the bluffs recede from the river, and are succeeded by low bottom-lands, elevated about three feet above the water. These continue within three miles of the confluence of the Kickapoo. On the south side, the hills run parallel with the Wisconsin River, with a narrow strip of bottom-land between, having an elevation, where they were measured, of three hundred and fifty feet. Near the summit, the cherty beds of F. 2 are occasionally exposed, in vertical walls, but the underlying beds are concealed by vegetation and soil.

On Section 16, of Township 7 north, Range 4 west, the strata occur in the following order:

	Feet.
1. Thick-bedded brown and yellow sandstone, ...	103
2. Alternations of sandstone and magnesian limestone; oolitic near the top,	35
3. Heavy-bedded magnesian limestone, ...	172

On the summit of the ridge, are loose masses of the upper sandstone, F. 2, c, but no strata are visible in place.

A mile further, low ledges of horizontal beds of sandstone alternating with magnesian limestone are seen on the north bank of the river. The layers are from two to six inches in thickness, and are traversed by vertical fissures. This exposure extends up the river for nearly a mile, varying in height from six to fifteen feet.

Some of the layers here consist of a siliceo-calcareo-magnesian rock, with green particles of silicate of iron disseminated, and contain casts of *Orthis*, and one of the species of *Dikelocephalus* found in the Lower Sandstone series of the Upper Mississippi; one bed seems to correspond to the brown Orthis rock in the section at La Grange Mountain.

A mile further up the Wisconsin, green and yellow layers of Lower Sandstone, F. 1, *d*, appear, having much the same lithological character and composition as on the St. Croix and Mississippi. In the upper thinly laminated layers, fifteen feet above the river, Lingulas occur, associated with a Trilobite, which appears to be the same as one of the species afforded by the third Trilobite bed of the Mountain Island section. The strata rise up stream, so that in a few hundred yards they attain an elevation of thirty feet.

The upland on this part of the Wisconsin is mostly wooded near the river, and the soil good.

About six miles above the last section, the bluffs were found to be three hundred and sixty feet high. The base has a talus of loose masses of brown, coarse-grained sandstone, interspersed with the soil. Some of these have siliceous concretions disseminated, apparently the remains of decomposed fossils; some specimens show the angular structure of the body-plates of Crinoidea. One hundred and fifty-seven

feet above the river, intercalations of magnesian limestone and thick-bedded sandstone occur, nearly as white as in the slope below Fort Snelling, though of course they occupy a lower position, being part of F. 1, *f*. The whole is surmounted by a perpendicular escarpment of one hundred and seventy-eight feet of Lower Magnesian Limestone.

This range of bluffs continues on the right bank of the river for about five miles. Thirty-one miles, by estimation, above the mouth, the bluffs measured two hundred and forty-four feet in height, and present a wall of forty feet of F. 2 near the top, with occasional exposures of sandstone seen beneath the slope. On the opposite side, a fine level plain extends, two miles wide, bounded on the south by a wooded range of corresponding bluffs, having a very regular outline. In this vicinity, the bottom-lands are generally well wooded and elevated four to eight feet above the water.

Near a ferry-house, eight miles below English Prairie, soft white sandstone, six feet in thickness, with thin shaly layers interstratified is shown, on the left bank; the former are in beds from three inches to a foot thick. These strata increase in elevation up stream, having a slight dip to the southwest. Thicker beds of white and brown sandstone rise to view one mile above the first exposure, where the ledges attain a height of twenty feet. The succession is

	Feet.
1. Coarse brown sandstone, in thin beds, broken by vertical rents or seams,	3
2. Thicker beds of the same, ...	5
3. Thin-bedded, ripple-marked sandstone, with marly partings, . .	12

I found here, in some of the loose slabs of sandstone, the pygidium of Trilobites, and a small, finely-striated *Orthis*, like the species which occurs in the third Trilobite bed near the mouth of the Miniskah. These ledges continue for a mile, with a slight southwest dip, and rise to the height of thirty feet. The lower strata resemble beds near the base of the Lawrence Creek Section; the superior layers seem to correspond with the inferior portion of the coarse Lingula and Obolus grit, F. 1, *c*. These bluffs prevail on the right bank for about half a mile, when well-timbered alluvial lands set in.

At English Prairie, the white and brown sandstone of the last section is seen near the water's edge, ten feet of it extending for half a mile. From one to two miles above the English Prairie Settlement, the Lower Magnesian Limestone is exposed, in a mural bench of fifty-six feet, near the top of the ranges of hills, which are three hundred and fifty to three hundred and sixty feet high, with eight feet of F. 1 above the river on the north side. Some outcrops of sandstone are seen projecting from the slope to the height of three hundred and two feet. For two miles, thick beds of sandstone can be traced, ten to twenty feet exposed. Some of the beds are so very white that they might well be mistaken for F. 2, *c*, if the associate beds could not be seen. At some points the lower beds have crumbled away, and left the upper projecting like an overhanging cornice. Half a mile higher up is a good exposure of the different strata, in the following order:

		Feet.
1.	Thick-bedded white and brown sandstone,	10
2.	Slope unexposed (probably the greensand-beds),	130
3.	White sandstone,	10
4.	Slope,	12
5.	White and brown coarse-grained sandstone, in heavy beds,	102
6.	Cliff of Lower Magnesian Limestone,	96
	Total,	360

From the summit of these bluffs there is an extensive prospect of English Prairie, which appears to be about two miles wide, bounded by a range of hills with graceful slopes.

About seven miles above English Prairie is Richland City, on the right, recently laid off, where there is a good landing for steamboats, the banks being about four feet high immediately at the river, but increasing in height a short distance back. The soil is light and sandy in the low lands, but improves in quality towards the bluffs. The population on this part of the Wisconsin is rapidly increasing.

Five miles above Richland (which is situated in Township 9 north, Range 2 west, of 4th Principal Meridian), soft, easily-crumbling, white and brown sandstone is exposed, fifteen feet thick, presenting a waved outline. Above these beds there is a gradual slope to near the top of the hill, which is capped with magnesian limestone, F. 2, which can be traced with some little interruption along the brow of the hills for two miles, gradually increasing in elevation, until it finally forms a mural escarpment of forty-five feet: dip slightly towards the east.

At the upper end of the exposure, a bed of five feet of micaceous white and green sandstone was found, at an elevation of forty-two feet, resembling in lithological character the beds at Mountain Island, above F. 1, *c*, and containing Orthis, Lingulas, and remains of Trilobites; also fucoidal-like impressions, in yellow, laminated layers. Under it are forty-two feet of heavy-bedded white and brown sandstone. The whole height of this hill is two hundred and fifty feet, and it appears to be composed entirely of different members of F. 1.

The river now winds for seven miles through alluvial lands, supporting a heavy growth of oak, hickory, bass, and maple, with a few pines and cedars. In Section 25, Township 8, Range 3 west, of 4th Principal Meridian, about a mile below Helena, the rocks are exposed at intervals, as follows:

		Feet.
1.	Thick-bedded white and brown sandstone, corresponding to the beds beneath the Trilobite-bed of last section,	50
2.	Slope, with fragments of green and yellow sandstone scattered over the surface,	34
3.	Soft, crumbling, white, yellow, and brown sandstone, in thick beds, with thin, ferruginous bands and spots,	22
4.	Slope, where no rock is visible,	49
5.	Intercalations of sandstone and magnesian limestone, in layers from four inches to two feet,	18
6.	Ash-coloured, siliceo-calcareous layers (St. Croix Trilobite-bed),	5

		Feet.
7.	Slope, where rocks concealed, ...	40
8.	Hard, brown sandstone, in thin beds, somewhat calcareous and magnesian,	8
9.	Slope, with occasional ledges of coarse-grained sandstone protruding in massive beds, ...	72
10.	Lower Magnesian Limestone, F. 2, ...	5
	Total, . . .	303

Bed No. 6 splits with a conchoidal fracture, and has cavities partially filled either with concretions of iron or blende. It has the lithological character of the Trilobite-bed on Lake St. Croix, and contains the same Lingulas.

From the above section it appears that on this part of the Wisconsin thick-bedded brown and white sandstones, containing but a few fossils, take the place of the coarse Lingula and Obolus grit, F. 1, *c*, of the Mississippi sections; and the same fact will appear from some of the succeeding sections.

For about fourteen or fifteen miles above Helena, no good sections present themselves.

On Section 20, Township 9 north, Range 6 east, of the 4th Principal Meridian, the following section was measured.

		Feet.
1.	Soft, white sandstone, passing upwards into coarse, brown gritstone, .	60
2.	Coarse sandstone, composed of angular grains of quartz, . .	4
3.	Brown, compact, calcareo-magnesian rock, with alternating beds of brown sandstone, ...	35
4.	Brown sandstone, rather fine-grained, ...	5
5.	White and brown sandstone, interstratified with siliceo-calcareo-magnesian rock, like the beds of No. 3, but more arenaceous; some green-sand disseminated, ...	87
6.	Partial exposures of sandstone, and thin layers of magnesian limestone,	26
7.	Slope, covered with vegetation and soil, and masses of brown, ferruginous sandstone, ...	48
	Total, . . .	265

The sandstone at the bottom of bed No. 1 is exceedingly white, being composed of limpid grains of quartz, loosely cemented, so that with a slight blow it crumbles easily to a white sand; the upper beds of No. 1 resemble the coarse Lingula grit of Lawrence Creek.

Bed No. 2 contains small, rounded, and angular concretions of ferruginous sand, and some particles of silicate of iron and ferruginous stains.

Bed No. 3 probably corresponds to the brown Orthis rock, No. 3 of the section at La Grange Mountain. Bed No. 6 has the lithological character of bed No. 4 of the La Grange Mountain section.

Two miles below Saukville, the hills near the river seem to be composed mostly of drift materials.

Nearly opposite Saukville, the hills are a little over two hundred feet high, and present the following section:

		Feet.
1.	Slope, where rocks concealed,	115
2.	Calcareo-siliceous sandstone,	10
3.	Soft, coarse sandstone, containing a layer of calcareo-magnesian rock,	15
4.	Soft, calcareo-siliceous sandstone,	5
5.	Calcareo-magnesian rock, with remains of Crinoidea, surmounted by	5
6.	White sandstone, with dolomitic intercalations,	
7.	Sandstone, with green particles disseminated, alternating with layers of magnesian limestone,	32
8.	Slope, unexposed,	19
	Total,	201

Opposite Upper Saukville, the hills on the river are again of drift, composed of loose sand and boulders of trap, porphyry, quartzite, granite, and masses of magnesian limestone, some of which would weigh several hundred pounds. Behind the drift-hills, which are upwards of one hundred feet high, rise higher hills, in which the rocks are partially exposed; and, one mile above Sauk Prairie, the Lower Magnesian Limestone forms a bold and rugged escarpment at the top of the bluffs, which are three hundred and sixty feet high, with drift-hills in the foreground, one hundred and thirty feet high, resting against the slope of the principal range of hills. Above the drift is a wall of sixteen feet of brown sandstone, with silicate of iron disseminated. Another wall, of eight feet of brown and white sandstone, and thin intercalations of magnesian limestone, projects fifty feet above the first. Between this latter and the cliff of Lower Magnesian Limestone, some oolitic beds are visible. Some of the beds of magnesian limestone at this place afford a good building material. The magnesian limestone, including the oolitic beds, is seventy-two feet thick.

The soil on the drift-ranges at this place is a dark sandy loam, probably somewhat calcareous, supporting a growth of tall grass and oak openings.

The drift-hills skirt the banks of the river for six miles above Saukville, and have an elevation of one hundred and five feet, at a point about two miles above the village, where they were measured; and two miles higher, one hundred and fourteen feet, where they are half a mile from the river, with bluffs of sandstone behind them, capped with sixty feet of rugged cliffs of magnesian limestone: their total height is three hundred and forty-one feet.

On Section 11, Township 10 north, Range 7 east, of 4th Principal Meridian, the bluffs are two hundred and fifty feet high. Above a slope of one hundred and sixty feet, where no rocks are exposed, the formation is of sandstone, F. 1, for ninety-three feet. At the base of the outcrop, the layers are white and yellow, and tolerably thick; near the top they are thin, ash-coloured, and the rock consists of coarse grains loosely cemented, and crumbling rapidly by exposure to the weather. On the summit are many erratic blocks of trap, granite, porphyry, and magnesian limestone. Similar boulders are found on the tops of the drift-hills, and lining the banks of the river, as far as Prairie du Sac.

The best soil is near the base of the bluffs; that near the river is light and sandy. On Section 2, Township 10, Plymouth is situated on a terrace of drift, which can be traced for two miles, succeeded by low alluvial lands.

Five miles above Plymouth, on the southwest corner of Section 28, Township 11, 8° east of 4th Principal Meridian, the bluffs come up to the river, and afford a good section, here given:

	Feet.
1. Talus, ...	5
2. Coarse brown gritstones, with ferruginous concretions, . . .	5
3. Soft, crumbling, coarse, brown sandstone, ...	15
4. Fine-grained, brown sandstone, with ferruginous concretions of the same,	5
5. Slope, rocks concealed, ...	88
6. Lingula and Obolus grit, white below, and thinly-laminated above, .	5
7. White sandstone, with small pebbles of quartz and felspar, . .	4
8. Coarse brown sandstone, " " " " " . .	5
9. Thick-bedded, light-coloured sandstone, ...	6
10. Brown, calcareo-siliceous rock, containing two species of Orthis, .	4
11. Coarse, ferruginous sandstone, with small pebbles of quartz, . .	4
12. Brown, calcareo-magnesian rock, with numerous columns of Crinoidea, green specks, and thin bands of brown sandstone, intercalated, .	12
13. Brown, mottled sandstone, with intercalations of white sandstone, .	24
14. Slope, no rocks exposed, ...	181
Total, . . .	363

The slope No. 5 probably contains crumbling beds of green Lingula gritstone; if so, one hundred and twenty-three feet of the base of the section represents F. 1, *c*, of the Mississippi sections, though not quite so fossiliferous as on that river. Bed No. 6 contains some pebbles of quartz and felspar as large as a walnut. No. 10 of this section corresponds to No. 3 at La Grange Mountain. No. 13 effervesces freely with acids, and is the most suitable for making lime.

Four miles above the last section we found another, as follows:

	Feet.
1. Coarse Lingula grit, and white and brown sandstone, ...	60
2. Slope, no rocks exposed, ...	83
3. Brown, calcareo-magnesian rock, with remains of Crinoidea, . .	10
4. Fine-grained, soft, brown sandstone, ...	9
5. Slope, no rocks exposed, ...	20
Total, . . .	182

The Lingula grits of this section form a wall on the river, scooped out at the base, so that the upper beds overhang the water. The Crinoidal beds are very nearly on the same level here as at the preceding section. Two miles higher up the river, the Lingula grit-beds are seen in a mural cliff of fifty feet. The sandy soil above supports a growth of pine and oak.

A mile above, the hills are one hundred and fifty feet high, with the same wall of Lingula grits at the base, on the river. This point is about one mile below Dekorra, where the sandstone is seen in cliffs of sixty-five feet.

Immediately below the mouth of the Barraboo River, the hills of drift are seventy feet high, and composed of sand, gravel, and small boulders; near Winnebago Portage, they are twenty-five to thirty feet. Between these two localities the Wiscon-

sin meanders through low alluvial lands. At the ferry, above the Portage, the drift-terrace is fifty to sixty feet high, with a light sandy soil on the top, inferior in quality to the adjacent bottom-lands. Behind this terrace of drift, the hills rise to the height of two hundred and fifty to three hundred feet.

Wherever the drift-hills approach the river, its banks are lined with boulders. About seventeen or eighteen miles above Winnebago Portage, the drift-hills attain a height of one hundred and twenty-five feet, with sandstone, F. 1, cropping out near the base. On Section 15, Township 13, Range 6, there is an exposure of sandstone on both sides of the river, which is the commencement of the Dalles of the Wisconsin River. The rock near the base is a soft, thick-bedded, white sandstone, easily denuded; this passes upwards into a yellow and ferruginous sandstone, of coarser grain, some of it almost oolitic, and the superior strata present, for a short distance, remarkable cross-lines of deposition.

Opposite Dell Creek, the wall of white, yellow, and brown sandstone is twenty feet high, and increases to thirty feet in a few hundred yards, in one mile to eighty feet, in three miles to one hundred feet, and in three and a half miles to one hundred and thirty feet. At this latter point, the rocks are traversed by dark, ferruginous bands, and again show cross-lines of deposition.

A mile above this, the Wisconsin River becomes contracted to seventy feet, being hemmed in by walls of sandstone, between which the waters rush with great velocity. Half a mile above this, the height of the sandstone is eighty feet, and the upper beds assume a reddish aspect, like those of the Dalles of Kettle River.

The length of the Dalles is about five or six miles, in which the height of the rocky walls varies from forty to one hundred and twenty feet, and in many places the rocks are washed and weathered into a variety of curious, fantastic shapes, often presenting the appearance of columns, surmounted by cornice and architrave, with intervening arches. In some instances the current has cut from the main cliff isolated masses, which now form islands, with precipitous sides, fifty to sixty feet high.

The soil on the tops of the cliffs is so sandy as to be almost unfit for cultivation, and supports a growth of small red pines and stunted oaks.

At the head of the Dalles, the rocks are one hundred and twenty feet high on the left, and seventy feet on the right bank. On the left, the sandstone continues, with about the same elevation, for about half a mile, when the main range leaves the river, sending out rocky spurs, which appear at intervals for about a mile further. On the right, the bluffs bear away from the river, immediately at the head of the Dalles, and can be traced for miles bounding the alluvial lands, which are nearly a mile wide in some places. The river now expands again to nearly its former dimensions, and meanders amongst a multitude of little islands.

From the extensive sandy plains that now set in, many remarkable isolated peaks rise, at distant intervals, some of which are almost vertical, to the height of two hundred feet and upwards. The first encountered was about two miles above the Dalles, which is one hundred and eighty-five feet high, its sides and summits dotted with pines and oaks. The rocks composing it are like those at the Dalles,

excepting the upper beds, which weather and split into prismatic blocks, from one inch to one foot in thickness, and stand out in the form of turrets.

From the summit an immense plain can be traced, apparently about thirty miles in extent, its uniformity broken at intervals of a few miles by these curious, isolated peaks of sandstone, most of which seem to have about the same elevation.

The plain is elevated about seven feet above the water.

About five miles above the Dalles, thirty-five feet of sandstone appears on the left bank of the river, and continues for a few hundred yards. Not far from this place there rises one of those isolated peaks, two hundred feet above the plain, like some time-worn castle, with turrets, towers, and battlements.

Two and a half to three miles further, the sandstones of F. 1 are again exposed; at first on the right bank, twenty-nine feet high; then on both sides, from fifteen to fifty feet high. The upper layers are thinly laminated; the lower are thicker, but soft and easily worn by the current, so that the superior strata often project, even as much as ten feet beyond the base. Here the soil is sterile and sandy, bearing a growth of small pine and scrubby oak.

The strata rise to the northwest, so that half a mile beyond this last exposure the sandstone is ninety-five feet high, presenting a mural face to the river. At several points the beds are intersected by vertical fissures, that traverse the rocks from top to bottom, and divide the strata into large square blocks. About eight feet above the river, a band of sandstone, of brick-red colour, contrasts strongly with white sandstone beneath.

Between two and three miles higher up stream, the rocks show themselves to the height of one hundred feet; here the dip begins to be reversed, and the rocks gradually decline to thirty feet, about one mile below Fortification Rock. This remarkable peak is situated on the right bank of the river, with an elevation of one hundred and fifty-five feet. On the northwest face is a perpendicular escarpment; on the southeast, there are a series of offsets and abrupt descents to the level of the plain. On the top, its length is about one hundred yards; its width, fifteen to twenty feet.

The inferior beds, composing Fortification Rock, are thick-bedded white and brown sandstones. At forty feet, the sandstone is red and ferruginous for twenty feet, passing upwards into a variegated rock, with brown, red, and white streaks, ten feet thick; over this, white and brown sandstones are again repeated. The red beds are hard and massive, without lines of stratification.

A little over a mile above Fortification Rock, sandstone is again seen, sixteen feet high. At the base it is soft, and of a deep red hue, with a few thin layers of more compact, chocolate-brown sand-rock, passing upwards into variegated sandstones, like those on Snake River.

Three miles further is Eagle Rock, which is a perpendicular wall of sandstone, of thirty feet; the lower layers yellow, surmounted by the red bands of the preceding section, then yellow and brown layers, containing ferruginous concretions, with fine-grained yellow sandstone on the top, some layers of which are ripple-marked.

The current has here also worn away the inferior strata, leaving the upper layers jutting out ten feet, like an entablature, supported at intervals by heavy columns,

extending down to the water. The soil above is light and sandy; the growth, only small pines and scrubby oak.

Beyond this exposure, the alluvial banks of the river are about ten feet high. From these bottoms there rises a gradual slope to a terrace of land fifty feet above the Wisconsin.

With the exception of some low ledges of rock, about four miles above this last section, there are no exposures for thirteen miles. Cliffs of variegated sandstone of F. 1 then again present themselves, with mural faces of about twenty feet, over which are two terraces of land, one about forty-five or fifty feet above the river, the other still higher, and consisting chiefly of sand. The rocks are still more singularly worn and weathered, so as frequently to produce the effect of a ruined temple, half sunk in the water. Two miles beyond this, a terrace of sand, with a few thin layers of ash-coloured clay, commences on the west side of the river, and rises to the height of twenty feet, continuing for three miles.

From this terrace Petenwell Peak can be seen, two miles off, looming up out of these sandy plains. It is the most elevated of all the isolated peaks measured on this part of the Wisconsin, being two hundred and fifty-five feet above the river. Its east face is nearly perpendicular; on the west is a very steep slope, one hundred and sixty feet above the surface of the plain, thickly strewn with immense blocks of sandstone. The north side is worn into several subordinate peaks, but little inferior in height to the main mass, being about two hundred feet above a creek which flows near their base.

The rocks near the summit of Petenwell Peak consist of coarse and fine-grained white, yellow, and ash-coloured sandstone, in thick beds, with some thin layers interstratified. The area of ground on the summit of the highest peak is only about twenty-four hundred square feet, its length being about two hundred feet, and its average width about twelve. The base of the exposure of rock is a mottled, ferruginous sandstone, with occasional concentric markings.

It is a matter of surprise to the spectator of this vast pile of sandstone—which is mostly soft, crumbling even with a slight blow of the hammer—how it should have resisted the denuding action which has swept away hundreds of feet of similar sandstone from around it. The explanation of the phenomena may perhaps be found in the fact that some of the beds seem to have a disposition to indurate by exposure, acquiring in time a hardened, vitreous surface, approaching to quartzite, which gradually incrusts the softer material within. We must suppose, therefore, that for a time the locality of the Peak was protected from the more rapid current which carried away the adjacent rocks, until gradually having acquired a more indurated face, it was enabled to withstand agencies which, in its original condition, must have inevitably ground it to sand, as they have done the adjacent strata.

The summit of Petenwell Peak affords an extensive prospect of the surrounding country. At its foot is spread out a gently undulating grassy plain, dotted with groves of oak and pine, with here and there a huge isolated peak, towering up like some artificial monument, commemorating the long lapse of time during which powerful currents must have circulated around them, gradually carrying away and

undermining a vast geological formation, of which these remarkable outliers remain to tell their history, and record one of the wonderful revolutions which have so frequently altered the configuration of the surface of our globe.

These various peaks are distant from each other from one to eight miles. Some are of an oval form, some rectangular, some conical, and most of them nearly of the same elevation. All do not rise in rugged and massive walls, and cliffs of rock, but present slopes, concealing more or less of the rocky beds, and even extending in some instances to their summits.

The landscape is bounded in the distance by a range of bluffs, presenting perpendicular faces where the rocks project from their flanks.

A similar country to that above described extends to Point Boss, which may be considered the limit, on the Wisconsin River, of this great sandstone formation, the elements of stratification of which I have been tracing out in the preceding pages.

Barraboo River.—My next examinations were directed to the Barraboo River, a stream which flows into the Wisconsin.

From Saukville, on the Wisconsin, I went by land to Adams, which I found upon inquiries was in the vicinity of the locality on the Barraboo, where copper ore was reported to have been found, to which place Dr. Owen's instructions particularly directed my attention.

On leaving the Wisconsin, we crossed a prairie of seven miles, the soil of which is a dark sandy loam, very suitable for agricultural purposes. We then ascended a ridge, and came upon massive cliffs of hard and compact quartzite, after ascending about eighty feet. This rock was exposed to the height of about fifty feet. The colour of the different beds varies from milk-white to reddish-gray. Some portions contain fine scales of yellow mica, and then approaches to Aventurine quartz. Veins of crystalline quartz, from one inch to several inches thick, traverse the rocks in different directions.

The whole height of the ridge is about three hundred feet above the level of the prairie. Huge angular blocks of quartzite, with occasional masses of conglomerate, can be traced to the summit, which rendered our route an exceedingly rough one. A few erratics were also interspersed amongst them.

In the midst of this great quartzite formation is a very picturesque lake, about a mile and a half long, and a little over half a mile wide, the long diameter running north and south. It is known by the name of Devil's Lake. The water is clear, of considerable depth, and contains a variety of fine fish.

The east and west shores are bounded, for a considerable distance, by rugged cliffs of quartzite, running nearly parallel to each other. The range on the west is five hundred feet above the lake, and six hundred and ninety feet above the Wisconsin River, the upper two hundred and fifty feet presenting a nearly perpendicular escarpment, from the base of which a very abrupt slope extends down to the water's edge, covered with immense angular blocks of quartzite. Near the south-east end is a descent by a succession of benches to the general level of the adjacent country. The range on the east side has nearly the same elevation, but does not

present a perpendicular escarpment, but merely a very abrupt slope or talus, amongst which a few pines have taken root.

This range of hills begins near the north end of the lake, and after skirting its shores for more than half its length, bears off in an easterly direction, and may be traced for many miles. A valley, elevated about two feet above the water, extends from the north end of the lake, gradually widening as it recedes from it. This valley is much more fertile than one would expect in the immediate vicinity of such hard, quartzose rocks. It is partly covered with a heavy growth of oak, and, as it widens out, it presents many fine sites for farms. Some portions of the rock in this valley are not indurated quartzite, but gray and reddish sandstones, nearly as soft as those on the Wisconsin, and amongst the loose blocks are many masses of a soft, friable conglomerate.

Soon after passing Devil's Lake, we began to descend from these ridges I have been describing, and, after travelling about four miles, reached the Barraboo River, at the town of Adams. Here, too, the soil is of good quality, supporting a heavy growth of oak, maple, ash, elm, and lind. The town, consisting of about sixty or seventy buildings, stands upon drift deposits.

From this place I proceeded in a northwest direction, through a valley bounded by hills varying from one hundred and fifty to three hundred feet in height. Three miles from Adams I found altered sandstones and quartzite, the former passing gradually from a coarse brown sandstone to a flinty quartzite. The rock is exposed both in naked cliffs and large angular blocks, and varies in colour from brown to a purple-gray, with occasional thin seams of milky quartz, which traverse the formation in various directions. The face of the cliff exhibits variegated parallel bands, conformable with the original lines of stratification. The base of the exposure is about eighty-six feet above the Barraboo, with one hundred and twenty-six feet of rock above. About a mile beyond this, the sandstone occurs in horizontal beds of eight to ten feet, exposed near the base of a hill sixty feet high. From the masses of rock of the same character thickly strewn on the slope, it is probable that the principal part of the hill is composed of beds of sandstone, equivalent to F. 1, *c*, as some of the masses resemble the Lingula grits near the base of the Mountain Island section.

For about six miles there is no section of the strata accessible, when about twenty feet of brown sandstone crops out, with some layers of a siliceo-calcareous rock interstratified, containing green grains of silicate of iron, and having the lithological aspect of the fucoidal layers of the Wisconsin section. On the top of the ridge, some ferruginous pebbly sandstone shows itself, containing some fossils; all but a Bellerophon were too imperfect to be able to characterize them. The height of this hill is about three hundred and twenty-eight feet above the Barraboo.

Barry's Copper Diggings are situated about two miles northwest of the above locality, on Section 1, Township 12, Range 14 east.

The ore is an impure carbonate and silicate of copper, with some copper pyrites, very similar to that analyzed by Dr. Owen from the vicinity of the Kickapoo; it occurs in "pockets," in F. 1, chiefly at a single locality, where, after the disintegra-

tion of the rock, it lies exposed on the surface in loose, rough masses, usually small, but occasionally six or ten inches in diameter.

Amongst the loose rubbish thrown from one of the "prospect holes" where the sandstone had been reached, I found numerous remains of Trilobites, like those which occur in F. 1, *d*, immediately above the Coarse Lingula Grit, seven miles above Richland, on the Wisconsin.

The position of the copper-bearing "pockets" seems to be in members *c* and *d* of F. 1. No regular veins have been discovered. Mr. Barry collected in all about eight hundred pounds.

About one mile beyond these copper discoveries the hills are two hundred feet high.

On Section 34, Township 12 north, Range 6 east, I found another quartzite range, bearing nearly east and west. Some part of this formation, near its base, is regularly stratified in layers from an inch to a foot in thickness, with a dip of about 15° to the southwest; above these beds, however, the massive cliffs of flinty quartzite exhibit no regular bedding. This range extends for more than a mile to within a short distance of the Second Mill on the Barraboo. Here, as at the other localities where the quartzite exists, veins of milk-white quartz traverse the formation without regularity as to bearing. The altitude of the range is one hundred and ten feet above the Barraboo.

Two miles and a half southeast of Adams, another quartzite range was traced by Mr. Pratten, precisely similar to those heretofore described, having a bearing nearly east and west, and an altitude of one hundred and fifty feet. Here the veins of milk-white quartz had a more regular disposition, running nearly vertically with a north-and-south bearing.

Four miles east of Adams, the sandstone is but slightly altered, and has a height of seventy-five feet; though much broken, the layers are stratified.

One mile beyond, in the same direction, ten feet of nearly white quartzite crops out at the base of the hills, exposed in layers of about one inch in thickness, and surmounted by thirty-five feet of sandstone; this again is overlaid by one hundred and fifty feet of reddish quartzite. From this point the quartzite ridge can be traced, bearing to the east, across the Barraboo, with an elevation of about four hundred feet above the river.

In the valley of a small creek, a mile and three-quarters southwest of the Barraboo, the encrinital calcareous bed* of F. 1 is seen in a quarry where it has been got out for the use of the limeburner. Its thickness is fifteen feet.

* An analysis of a specimen from this bed yielded:

Carbonate of lime,	50·00
Carbonate of magnesia,	41·70
Insoluble earthy matter,	3·10
Alumina, oxide of iron, etc.,	2·60
Water,	1·00
Loss,	1·6
	100·00

CHAPTER IV.

OBSERVATIONS ON SNAKE, KETTLE, AND RUSH RIVERS.

Snake River.—Near the mouth of this stream, the hills, which are about fifty feet high, are composed, as far as can be seen, of loose sand.

The first rock exposure occurs about half a mile above its confluence with the St. Croix. The base of the section is a coarse-grained quartzose sandstone, of a light brown colour, the grains of which are loosely cemented by a siliceous paste. On this reposes a coarse, pebbly sandstone; the pebbles, which are of quartz, vary in size from a pea to an almond, and are cemented with coarse sand. This latter bed is two and a half feet thick, and supports nine feet of ash-coloured sandstone, with brown spots disseminated, and traversed occasionally by ferruginous bands. The stratification at this place is horizontal. Over the rocks is about twenty feet of loose sand, of a light red colour, with boulders of trap towards the summit.

Half a mile further, sandstone again appears, fifteen feet thick, similar in appearance and colour to the beds on the St. Croix, below the mouth of Wood River, and softer than the rocks at the previous section. At neither localities was I able to detect any fossils.

Two miles further, the same rock shows itself, but only in a low wall, just above the water's edge.

A succession of rapids commence at the mouth of the river, and continue, with little or no interruption, for six miles; and the shores and beds of the stream are generally lined with boulders of dark porphyritic trap, containing crystals of epidote, fine and coarse-grained granite, syenite, micaceous slate, and red sandstone. The soil is for the most part light and sandy, but the alluvial lands bear a dense growth of hard and soft maple, ash, elm, basswood, and large pines, with a thick undergrowth of hazel and prickly ash.

At the head of these rapids there is slack water for about half a mile; the rapids then set in again, and continue to Lac Travers.

The first exposure of trap in place is three miles below the lake; it rises, however, only a few feet above the water. A mile further, a gray compact trap is elevated eight feet out of water, which is followed, a mile still higher, by eighteen

feet of conglomerate, such as usually accompanies the trap-rocks further to the north.

Half a mile below Lac Travers a range of compact greenstone trap crosses Snake River, bearing northeast and southwest. The rock is traversed by many veins of calcareous spar, from a fourth of an inch to two inches thick, but no accompanying metal was discoverable, so far as they are exposed to view.

The soil overlying this trap range is of good quality, and supports a dense growth of maple and other varieties of hard wood timber. From the former, the Indians manufactured in this vicinity considerable quantities of sugar.

A few hundred yards below the lake, the elevation of the trap is about eight feet; nearer the lake, fifteen feet, the bearing northeast and southwest. In lithological character it is similar to the range three miles above the mouth of Kettle River, and appears to be its southwestern extension. At both these localities the trap is accompanied by brown amygdaloid, and intersected with spar veins. The cavities of the amygdaloid contain epidote and a green mineral, nearly as soft as tallow, when first collected, but brittle after exposure to the air. The rocks are much broken and shattered, and disintegrate rapidly by atmospheric agencies.

Lac Travers is a fine sheet of water, four to five miles in length, and about three-fourths of a mile in width, the long diameter running nearly north and south. The shores vary from three to eight feet in height, and bear a heavy growth of pine.

For five miles beyond this lake the lands bordering Snake River are low and wet, the growth pine, tamerack, aspen, elm, soft maple, and lind.

Lake Pokegoma is situated about six miles above Lac Travers, and has an outlet into Snake River about one hundred feet wide. It is a beautiful expanse of water, about five miles in length, and upwards of a mile in breadth. The shore on the south is from ten to twelve feet high, and is lined with boulders of granite, syenite, and porphyritic trap. On the east, west, and south there are gradual wooded slopes.

For twenty-one miles we observed no rocks in place. The first exposure that we encountered after leaving Lac Travers is three miles above Fishing Creek, where eleven feet of a coarse, gray, thin-bedded sandstone shows itself, some of which has rounded quartz pebbles disseminated. It dips with a considerable angle to the northeast.

From an Indian village which is nearly opposite Fishing Creek, the land rises gradually to the height of fifteen to twenty feet. Some of the layers of sandstone a few hundred yards above, where they first appear, contain pebbles of granite, porphyry, jasper, and brecciated quartz. The dip of the strata, a quarter of a mile above, is about 5° to the northeast, but increases in proceeding up stream. A short distance further, near where Knife River crosses Snake River, I found the successions as follows:

1. Thick-bedded, coarse-grained, gray sandstone, with siliceous pebbles disseminated.
2. Thin beds of the same, with coarse pebbles.
3. Thin layers of a kind of inferior red pipestone.

This locality is about a quarter of a mile below the confluence of Knife River, a

stream of about fifty feet in width at its mouth. Between Fishing Creek and this place, Snake River is almost one succession of shallow rapids, its bed being covered with boulders to such an extent, that it became frequently necessary to make a channel for our bark canoe by the men getting into the water and removing them.

For about nine miles above Knife River, both shores are lined at intervals with a dense and heavy pine forest, succeeded again by two miles of low bottoms, five to six feet above the water, bearing a growth of oak, ash, elm, and occasionally white walnut and soft maple, with a dense undergrowth of hazel. Beyond this, pine ridges approach the river, and prevail for several miles.

For thirteen miles no rocks were observed in place; then twenty-five feet of red sandstone, alternating with ash-coloured clays, are exposed, covered with seventeen feet of stratified gravel and sand.

No more ledges of rock are again seen for about thirty miles by water above Knife River, but the navigation of Snake River, in this distance, is much obstructed by frequent rapids, over and amongst blocks of erratics. Here sandstone again shows itself, but only in low, thin-laminated layers, which correspond to No. 2 of the last section, above the mouth of Knife River. A few hundred yards higher up stream, the height of the sandstone is eight feet, and lower layers come to view, rather coarser-grained than the superior strata, and made up of grains of the constituents of granite,—quartz, felspar, and mica,—from the destruction of which rock these sandstones are evidently derived. The beds are much broken and disturbed, dipping sometimes as much as 15° to the northeast.

After proceeding about nine miles farther without being able to discover any rock in place, the high ground being entirely of drift, I found myself compelled to return, both because the river was now too shallow even for canoe navigation, and because our provisions were exhausted. My own observations on this stream, and those of Dr. Norwood on his overland route from St. Louis River to Lake Pokegoma, indicate the last section as the bounds of the sandstone formation in the valley of Snake River, before it is entirely concealed by drift and erratics, until it again appears on the St. Louis River.

On Snake River there are some magnificent pine forests, finer, indeed, and of greater extent than I recollect to have observed in any portion of the district allotted to me for examination.

The general elevation of the upland bordering the river does not often exceed twenty feet, and the bottom-lands vary from three to ten feet. The soil, except in the immediate neighbourhood of the trap ranges, is, for the most part, light and sandy. Neither the structure and contour of the country, nor the character of the igneous ranges, afford encouragement to the miner, the only evidence of the existence of copper in this river being a few pieces found amongst the erratics.

Kettle River.—The first rock which shows itself in ascending this river is a mile and a half above the mouth, where a ledge of reddish-gray conglomerate crops out on the left bank of the river, composed of siliceous pebbles, varying in size from that of an almond to that of an egg, very loosely held together.

Two miles and a half above the mouth is the first trap range, which appears on

the right bank of the river, bearing northeast and southwest, with an elevation of fifteen feet above the water-level. A mile higher up, another range of greenstone trap, associated with amygdaloid, forms perpendicular walls on the river, for about a quarter of a mile. Here the trap assumes a subcolumnar structure; and presents numerous vertical and transverse fissures, filled with calcareous spar, in which, however, no copper ore could be detected. The cavities of the amygdaloid contain both epidote and the same soft green mineral mentioned while describing the corresponding range on Snake River. Over the trap is about twelve feet of drift, supporting a light sandy soil. The growth of timber on the ridge is chiefly white and red pine and scrubby oak; while on the bottoms, where the soil is richer, pine trees were observed, four feet in diameter, interspersed amongst oak, elm, hard and soft maple, birch, and aspen.

Five and a half miles up Kettle River, conglomerate is again exposed, similar to that observed near the mouth, accompanied, a few hundred yards above the latter place, by trap rocks.

The navigation of Kettle River is interrupted for eight miles, as well by numerous boulders as by a succession of rapids, with only occasional intervals of smooth water.

For five miles above the trap range the soil is of good quality, and supports a luxuriant growth of maple, elm, and oak; then succeeds fine forests of pine, for several miles, interrupted occasionally by groves of oak and maple.

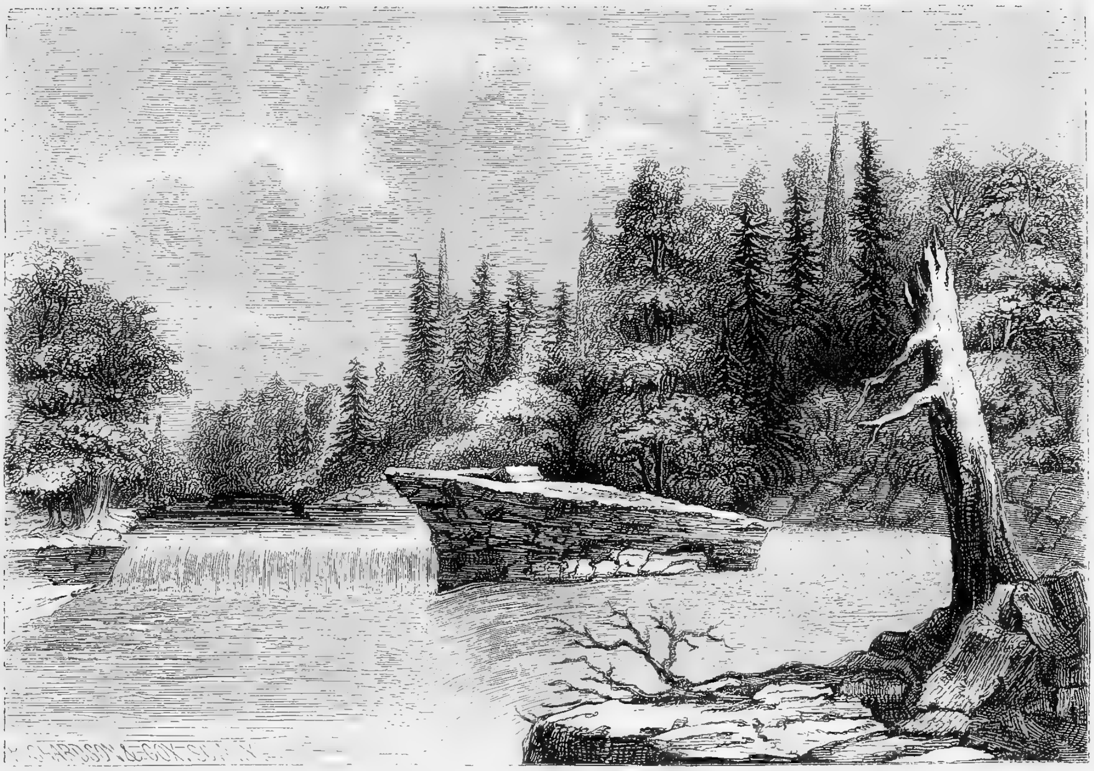
Between seven and eight miles above the rapids, a third trap uplift appears, on the left bank of the river, for a quarter of a mile, presenting a mural face of about thirty feet. Its bearing is nearly the same as the preceding.

Three miles higher, where the current runs with great swiftness, trap is again exposed on the left bank, and after reaching the head of the rapid, reddish-brown sandstone is encountered, on the same side, partaking much of the characters of some of the members of F. 1, as they occur on the Mississippi and Wisconsin Rivers, though more highly coloured, and rather more compact. Along the whole course of this exposure the strata have suffered considerable disturbance from the adjacent igneous range, being both tilted and fractured in various directions. The prevalent dip is to the northeast, but the inclination is not uniform.

Some of the sandstones here are finely ripple-marked, like those brought from Lake Superior near the mouth of Montreal River.

After passing a very swift rapid, estimated to be about twenty-eight miles up Kettle River, we reached the "Falls of Kettle River." An escarpment of from ten to fifteen feet of sandstone extends the whole distance of this rapid, traversed by fissures and deep chasms. The river, which is about one hundred and twenty yards wide above the Falls, is contracted in width, as it enters the gorge, to forty yards; widening somewhat as it approaches the cascade, it divides into two sheets around a triangular rocky island. The woodcut, on the next page, after a sketch by Mr. Meek, conveys a better idea of the appearance of the scene than any written description.

For half a mile above the Falls the sandstone disappears, and then again forms a wall, at first ten feet high; but gradually increasing in height, it attains an elevation of one hundred and fifty feet, about a mile and a half above the Falls.



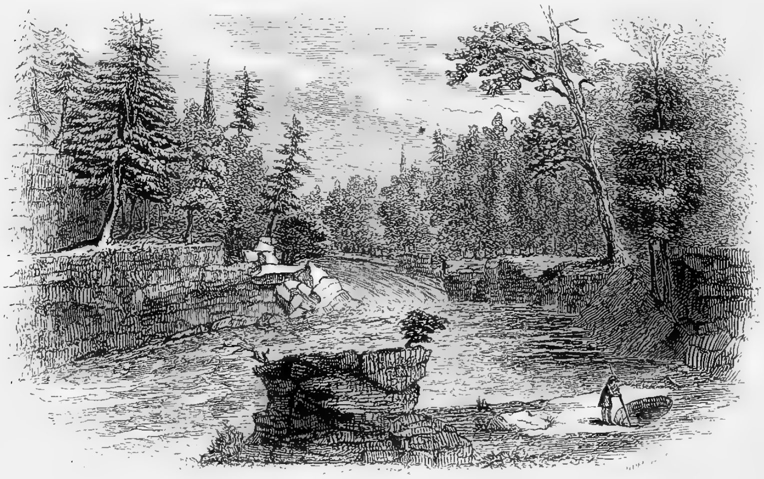
FALLS OF KETTLE RIVER.

Rapids again set in, about three-quarters of a mile above this point, and continue more than half a mile, between cliffs of sandstone from fifty to one hundred feet in height. The strata are traversed here by immense rents, sometimes twenty feet wide, and twenty-five feet deep. Some of these are hollowed out by the swift current of the river into large chambers and recesses, arched over by huge blocks of sandstone; and, on the summit of the cliffs, there are many pot-holes, one of which measured ten feet in diameter and fifteen feet deep. Here the river is contracted to less than fifty feet, and rushes between the sandstone dalles with immense velocity in times of freshets. Another sketch by Mr. Meek, on page 528, illustrates this scene.

For several miles above this, sandstone is of frequent occurrence, varying from fifteen to twenty feet in elevation, and rising to about eighty-five feet a short distance back from the river.

The soil here, even on the ridges, is of fair quality, and the land is well timbered, the prevailing growth being sugar-maple, red and mountain maple, red and yellow birch, linden, aspen, white and black spruce, with a few white and red pines; and moosewood was observed in this vicinity for the first time on this river. The narrow belt of land between the river and the ridges is exceedingly sandy, from the crumbling of the adjacent rock, but sustains a heavy growth of white and red pines, some of which were nearly four feet in diameter.

The navigation of Kettle River, above its Second Falls, is almost impracticable for canoes. The remaining examinations were, therefore, necessarily made by land,



DALLES OF KETTLE RIVER.

though the opportunities for obtaining good sections is always best in this country in the cuts exposed by the streams.

At the Second Falls, the river is also divided by an island, of about two acres in extent. The perpendicular fall is between two and three feet on the left chute, but on the other side there is a descent of eight to ten feet in as many yards. Occasional exposures of sandstone are seen above the Falls, and eight miles to the northeast, it is exposed in thick beds, fifty to eighty feet high.

From that point the ridges decline in elevation above the river: three miles further northeast, they were only thirty feet high. The land, too, becomes poorer, and the growth of aspen, pine, and balsam, more stunted; and about three miles further, the flat, marshy lands commence.

The furthest point up the valley of Kettle River where the sandstone can be traced, is about twenty miles above the Second Falls, where there is an outcrop of about fifteen feet. Beyond this the country is overspread with drift, and often covered with erratics. These incumbrances, together with the frequent occurrence of tamerack swamps, render the country, towards the head waters of Kettle River, of little value to the agriculturist, and deficient in interest to the geologist.

In none of the stratified rocks inspected on Kettle River, was I able to find any organic remains, but the pebbly beds resemble those on the Chippewa and Black Rivers, near the base of F. 1. The colour of the rock is usually deeper, varying from a fawn to reddish brown, and is not unfrequently ripple-marked.

Rush River.—From the examinations of Mr. Meek, to whom was intrusted the explorations of the surveyed townships situated in the Rush River country, I extract the following, in reference to the extent, thickness, and mineral character of the Magnesian Limestone (F. 2) in that district.

In Township 27 north, Range 16 west, of the 4th Meridian, F. 2 rises to the height of eighty-two feet above the level of Rush River, and is surmounted by twenty feet of white sandstone, F. 2, C. The magnesian limestone, in its upper

part, consists of thick and thin layers, with numerous spheroidal concretions embedded, and the strata are arranged in horizontal beds. In Section 30, F. 2 occurs in bluffs, on both sides of the river, and sometimes attains to the height of ninety feet. In the northeast corner of Section 31, this formation is again exposed, and is somewhat cherty; also in Section 32, where the magnesian limestone is elevated to the height of one hundred and fifteen feet above the margin of the river.

In Township 26 north, Range 16 west, there are exposures of F. 2 in the following sections, viz.: in Section 5, high cliffs appear near the southeast corner. In Section 8, the magnesian limestone occurs on both shores of the river. At a place called Balsam Bluff, in the northeast corner of this section, the strata form bold and overhanging cliffs, and rise to the height of two hundred feet above the margin of the stream. The base consists of thirty-five feet of alternations of sandstone and magnesian limestone, surmounted by thick beds of magnesian limestone, which is somewhat cherty towards the summit of the cliff, and is traversed by thin, vertical fissures, devoid of calcareous spar. Half a mile below Balsam Bluff, in the same section, these strata were found to attain nearly the same thickness. In Section 9, on the east side of the river, and near the line which separates it from Section 16, there is a precipitous exposure of F. 2, consisting of alternations of sandstone and magnesian limestone at the base, with thicker beds of the latter towards the summit. In Section 16, these strata form bold escarpments at a number of points on either side of the river, and in the southern portion are underlaid by F. 1, occurring in thick-bedded layers. On the east side of Section 17, near a small stream flowing from the southwest, are perpendicular cliffs, eighty feet in height, of which there is at the base thirty-five feet of alternations of sandstone and magnesian limestone. Near the mouth of Cane Creek, in Section 21, the upper members of F. 1 are exhibited in perpendicular cliffs, surmounted by the lower beds of F. 2, the latter forming the greater part of the exposure. In Section 22, a bluff, two hundred feet in height, was observed, composed, at the base, of F. 1, in thick-bedded layers, thirty-three feet through, capped with F. 2. In Sections 15 and 16, magnesian limestone is seen projecting from the hills on either side of Cane Creek; and in Section 11 the same rocks were again seen on both sides of the small creek which traverses it. In Section 27, the rocks were observed to be quite cherty in their lithological characters, on the shores of the small creek which runs through it. In Section 28, the Lower Magnesian Limestone occurs at various points, capping the hills of Rush River; also on the north side of a large creek, flowing westwardly, in the southwest part of the section; at this point F. 1 was seen underlying F. 2. In Section 33, high bluffs occur on both shores of the river. Mr. Meek found the rocks here to be more cherty than at any point further up the river. He also saw many imperfect specimens of fossils, such as characterize the cherty beds in the half-breed tract opposite the mouth of the Chippewa River. The rocks in Sections 34 and 26 present the same characters as those in the foregoing section.

The greater portion of Township 26 north, Range 14 west, of the 4th Principal Meridian, is underlaid by F. 1. The Lower Magnesian Limestone (F. 2) not being well exposed, its eastern boundary could not be defined with a great deal of accuracy; and in determining its limits in this direction, as laid down on the map, Mr.

Meek was governed by the features of the country, and the occasional occurrence of loose masses of F. 2 scattered over the surface. It was, however, seen in place on both shores of Missouri Creek, also in Sections 4 and 33.

In Township 26 north, Range 15 west, F. 2 was observed on both sides of a small stream which runs through Section 2, and in Sections 33 and 34, loose masses of this formation were found near the summits of the hills. In the latter section, this rock was also found in place on the southeast corner, at several points, but did not attain to any considerable altitude. On the north side of Section 1, loose masses were again observed, and in the northwest corner of Section 2 it was seen in place on a small creek, reposing on F. 1. In Sections 3, 24, 13, and 23, the Lower Magnesian Limestone was also observed in place.

On Section 36, Township 27 north, Range 15 west, F. 2 occurs on both sides of the L'eau Gallée River, near the tops of the highest hills. In Section 35, it was seen on the west side, and the northeast and southeast corners. In the former it is somewhat cherty. In Section 34, large loose masses of F. 2 were found scattered over a hill in the northeast corner. In Section 26, near the top of a hill, two hundred and seventy-three feet in height, in the southwest corner, these rocks were seen in large loose masses, somewhat cherty; but it could not be ascertained how much of the hill was composed of F. 2. In Section 27, loose masses, similar to those in Section 26, were noticed near the summits of the hills, on both sides of the river. In Sections 22 and 26, the Lower Magnesian Limestone was observed on the west side of the river; and in Section 16, these rocks were found to occur on both sides. Near the south part of this section, and on the east side of the river, there are hills two hundred and seventy-five feet in height, near the summits of which the Lower Magnesian Limestone was exposed in thick beds. In Section 8, the rocks were seen on either shore of the river for the whole distance that it traverses the section; and in the northwest corner, the hills attained to the height of two hundred and forty feet, with an exposure of about twenty feet of F. 2 at the summit. In the northeast corner of Section 7, the hills are crowned with loose masses of magnesian limestone, with an occasional exposure of this rock in place. In Section 6, loose masses were seen towards the summits of the hills on the west side of the river, for the entire distance that it courses through the section; and at a few points the rocks were seen *in situ*, forming, however, only low ledges, about twenty feet in height. The upper beds of the formation were not observed anywhere in the township, the middle or cherty members being alone exposed. They are not, however, so cherty as the equivalent strata on Rush River.

None of the beds of F. 1 were exposed in the township, though from the rounded outline of the hills, and the gentle character of the slopes, it is quite probable that this formation constitutes the underlying rock throughout its greater portion. Along the eastern branch of L'eau Gallée River, F. 2 was exposed at various points, and was found to extend as high up the stream as Sections 10 and 11.

From previous examinations, made by the different members of the Geological Corps, with reference to the lithological appearance of the beds of F. 2 which were lead-bearing, it was ascertained that where the strata were much broken and tra-

versed by fissures, and contained cherty masses, with cavities occasionally lined with drusy crystals of ferruginous quartz, and had also veins or nodules of calcareous spar disseminated, there was a prospect of finding this mineral. In the examination of the above townships, Mr. Meek searched with a great deal of care for the beds possessing these characters, and noted the sections in which they were observed to occur.

In the following sections, these appearances were well marked, viz.: in Sections 26, 27, and 34, of Township 26 north, Range 16 west, of the 4th Meridian, and they may be designated as being more likely to yield lead than any which were examined in the subdivided townships. In the townships which were not at that time subdivided, in the Rush River district of country, the rocks were observed to present these lithological characters at a number of points. In Townships 24 and 25 north, Range 16 west, we may mention that the appearances of the rocks in some portions were considered quite favourable for the occurrence of lead ore. In fact, in descending Rush River, from near the southern boundary of Township 26 north, Range 16 west, and especially on the east side of the river, the lead-bearing appearance of the strata becomes more and more manifest. But in the ascent of the stream above this point, the indications are less strongly marked, and at length disappear altogether.

No deposits of sand and gravel were observed anywhere in these townships, and only occasionally a few small boulders of greenstone trap, granite, &c. The growth consists chiefly of sugar maple, linden, several species of oak, white walnut, black ash, red ash, red elm, yellow birch, cherry or black birch, paper birch, and red birch.

In Section 18, Township 27 north, Range 16 west, some white pine was observed; also along the rocky bluffs throughout nearly the whole course of Rush River. In Section 34, Township 26 north, Range 16 west, this species occurs quite abundantly, and of good quality for lumber; also on the east side of Rush River, in the north part of Township 25 north, Range 16 west. On the L'eau Gallée River, it occurs in Township 26 north, Range 14 west; but the principal part, which is of any value for lumber, has been cut down. In Township 27 north, Range 15 west, it is also abundant and of good quality.

The southern portion of the Rush River country possesses many valuable sites for farms, especially where the calcareous rocks of F. 2, underlie the soil and subsoil, and the country is better supplied with timber than most parts of the prairie regions of these latitudes.

DR. J. LEIDY'S MEMOIR.

DESCRIPTION

OF THE REMAINS OF

EXTINCT MAMMALIA AND CHELONIA,

FROM NEBRASKA TERRITORY,

COLLECTED DURING THE GEOLOGICAL SURVEY UNDER THE DIRECTION OF DR. D. D. OWEN.

BY JOSEPH LEIDY, M.D.,

OF PHILADELPHIA.

TO DAVID DALE OWEN, M.D.,

UNITED STATES GEOLOGIST.

SIR: In the accompanying Memoir will be found a description of the fossil Mammals and Reptiles collected in the Mauvaises Terres of Nebraska, during the Geological Survey made under your direction, and which you submitted to me for examination.

Yours, &c.,

JOSEPH LEIDY.

DR. LEIDY'S MEMOIR.

The region of Nebraska Territory of the United States appears to be as rich in the remains of Mammalia and Chelonia of the Eocene period as the deposits of the same age of the Paris basin. Dr. Hiram A. Prout of St. Louis, described the first mammalian fossil from Nebraska, in the American Journal of Science for 1847. The specimen indicates a species of Palæotherium, or of a closely allied genus of gigantic size, and has been named after its discoverer, Palæotherium Proutii, *Owen*, *Norwood*, and *Evans*. Since the account of this fossil was published, an extraordinary number of beautiful and highly important specimens, of new species and genera of extinct Mammalia and Chelonia have been derived from the same locality, through the combined influence and labours of Messrs. Joseph and Thaddeus Culbertson, Professor Baird, Drs. D. D. Owen, Norwood, and Evans, and Dr. H. A. Prout and Professor O. Loghland. The most valuable collection, obtained by Dr. Owen's survey, forms the basis of the following descriptions, and comprises numerous specimens of eight species of six genera of Mammalia, and four species of the chelonian genus Testudo.

All the genera of Mammalia are distinct from those now in existence, and half of the number are new to Palæontology.

Among all the specimens which have come under my observation from Nebraska, one only belongs to a true carnivorous animal, and this is the Machairodus primævus, *Leidy* and *Owen*.

All the other mammalian fossils belong to the order Pachydermata, as Palæotherium and Rhinoceros, or to this order combined with ruminating characters, as in the case of Oreodon and Eucrotaphus; or to the same order in combination with decided carnivorous characteristics, as in the Archæotherium.

Most of the bones and their fragments are in a relatively good state of preservation, and are highly mineralized. Those of smaller animals are less fractured and mutilated than those of larger animals. The latter in many cases are crushed, while the fragments still retain their relative position, and the interstices filled

with mineral matter, indicate that they have been submitted to great pressure or violence, while embedded in the deposit in which they are found when this was in a soft state, or in the condition of mud.

The specimens are very dense, and in many of them the Haversian canaliculi and areolæ, and in the case of the long bones the medullary cavities, are filled partially or completely with silex. In the latter positions, the silex is sometimes beautifully crystallized, or has a botryoidal, chalcedonic arrangement.

The change which has taken place in the chemical constitution of these fossilized bones has been determined through analysis by Dr. Owen, and is given in his report.

OREODON. *Leidy.*

(Tab. x., 4–6; xi. 2, 3; xiii., 3–6.)

In Volume IV., page 47, of the Proceedings of the Academy of Natural Sciences of Philadelphia, I described a fragment of an upper and lower jaw, from the Bad Lands of Nebraska Territory, presented to the Academy by Mr. Joseph Culbertson. The former fragment contained the two posterior molars, the latter the three posterior molars, and upon them was characterized the new genus and species Merycoidodon Culbertsonii. In 1851, I received from Professor Baird of the Smithsonian Institution, and Dr. Hiram A. Prout of St. Louis, several fragments of skulls and jaws from Nebraska Territory, having the same form of true molar teeth characteristic of Merycoidodon; but being misled by a fragment of a face of a young animal containing a portion of the first permanent premolar, followed by the entire first, and a portion of the second deciduous premolars, and portions of the deciduous true molar, and first permanent true molar, in a verbal communication to the Academy,* I stated that the specimens belonged to two other distinct genera, to one of which the name Oreodon was applied, of which two species were designated: *O. priscum*, and *O. gracile;* to the other, that of Cotylops, distinguishing the species as *C. speciosa.* All these have since been satisfactorily determined to belong to two species of one genus, for which I propose to retain the name Oreodon, as being less exceptionable than that of Merycoidodon; for it will be observed, from the anatomical details presented in the succeeding pages, that the animal was a true Ruminant, and did not merely resemble one in the form of its true molar teeth.†

The abundance of remains of Oreodon found associated with those of Palæotherium, Rhinoceros, Machairodus, etc., in the Eocene formations of Nebraska, lead to the impression that it completely replaces the Anoplotherium of Europe. We have in possession, and belonging to the collections of the Smithsonian Institution, Dr. D. D. Owen of New Harmony, Indiana, and Dr. Hiram A. Prout of St. Louis, Mis-

* Proc. A. N. S., vol. v. p. 237.

† After detecting the error just related, it was some consolation to me to find that even some of the most distinguished of modern anatomists have been misled under exactly similar circumstances, to the special cases of which I think it needless to refer.

souri, crania and fragments of crania, and jaws with teeth, more or less perfect, of at least twenty-six different individuals of at least two distinct species of Oreodon. From this abundant material we are enabled to trace out almost all the anatomical details of the head of the animal, which I shall do without the unnecessary reference to particular specimens in the course of the description.

The head in its general form (Tab. x., 4–6; xi., 2, 3), resembles more that of the Camel than of any other existing Ruminants. It has an almost unbroken arch of teeth in both jaws, composed of molars, canines, and incisors. The head of one of the species of Oreodon is about the size of that of the Wolf of Pennsylvania; the other is about the size of that of the Badger. To the former I have given the name of *Oreodon Culbertsonii*, to the latter that of *Oreodon gracile*. The characters common to both the species mentioned, I shall now proceed to give in detail as belonging to the genus, and afterwards point out the specific differences in addition to the size.

Side view of the skull.—(Tab. x., fig. 5; xi., fig. 2.) The temporal fossa is constructed like that of the Camel, and is relatively about as large as in that animal. It rises to the middle line of the cranium, upon a parietal crest extending the whole length of the single parietal bone. Posteriorly, it is bounded by an oblique ridge, separating it from the occipital surface. Antero-superiorly, it is bounded by a slight ridge running outwards upon the post-orbital process. The surface generally is convex, is most prominent along the course of the squamous suture, and nearly one-half of its extent is constituted by the squamous portion of the temporal bone, as in the Camel and Lama.

In some of the specimens, the parietal bone along the course of the squamous suture and contiguous to it is depressed into a groove.

The zygomatic arch is relatively much broader and stronger than in any existing Ruminants.

The malar bone is robust, and its outer surface presents upwards and forwards, or is on the same plane with the orifice of the orbit.

The post-orbital process is united, as in existing Ruminants, with the malar bone, so as to form a narrow arch.

The orbital entrance is subrotund, and is directed forward to about the same extent as in the Deer, but in a trifling degree more upward.

The face at its lower part, in comparison with that of the Deer, appears not only shortened to an extent equal to the vast unoccupied space anterior to the molars in the latter animal, but appears also to recede so as to bring the last molar on a line perpendicular to the post-orbital arch.

The face, from the latter on each side forwards, forms an almost equilateral triangle. Its sides are more vertical than in the Deer, and form a continuous convexity from the middle nasal suture downwards.

The most remarkable feature in the lateral view of the face is the very large lachrymal depression, which is nearly hemispherical, and extends slightly beyond the borders of the lachrymal bone.

The infra-orbital foramen is situated above the third premolar tooth.

The anterior extremity of the floor of the nose constituted by the superior incisive

alveoli is convex, and resembles more that of the Anoplotherium than of any existing Ruminants.

Superior view.—(Tab. x., fig. 6.) In this view of the skull it resembles in its form more that of the Wolf than of any existing Ungulates. The parietal crest is relatively about as high as in the Camel. It bifurcates at the coronal suture into the ridges bounding the temporal fossa upon the post-orbital processes.

The forehead is relatively narrower than in the Deer, but broader than in the Wolf, and is more convex than in either.

Upon each side of the frontal suture, and nearer the anterior than the posterior extremities of the frontals, is a large supra-orbital foramen. The form of the muzzle in advance of the orbits is like that of the Musk-deer, except that it is more convex laterally.

The anterior extremity of the nasal bones is broken away in all the specimens, so that the form of this portion of the face cannot be ascertained.

Posterior view.—The occipital surface is intermediate in form to that of the Musk-deer and Wolf, and is smoother and relatively narrower than in the latter. Its lateral margin separating it from the temporal fossæ, is formed above by the conjunction of the parietal and occipital bones, and below, as in recent Ruminants, by the combination of the posterior temporal crest with a superficial process of the petrosa, wedged in between the former and the corresponding margin of the occipital bone.

The occipital condyles have very much the same form and relative position to each other that they have in the Deer, but are narrower and more prominent inferiorly.

The occipital foramen is rather transversely oval, with nearly vertical sides, and emarginate above. Its inferior margin between the condyles is placed more posteriorly in its relation to the superior margin than in the Deer, so that the foramen is directed more backward.

Inferior view.—(Tab. x., fig. 4.) The basilar process is prismoid, very much depressed laterally from the level of the occipital condyles, with the sides looking outward, and the middle prominent. The surface of the sphenoidal bodies incline very gradually upward and forward.

The para-mastoid process forms the infero-lateral termination of the occiput, and relatively to that of recent Ruminants is very long and strong. It is elongated pyramidal, bent a little forward and outwards, and is longitudinally excavated antero-externally.

The mastoid process forms the posterior boundary of the meatus auditorius externus, and projects downwards between the auditory process and the inferior extremity of the occipital process of the os petrosa.

The os tympanica is moderately developed, and abuts posteriorly against the base of the para-mastoid process. The stylo-mastoid foramen occupies the same relative position as in the Deer, and internal to it is a depression for the styloid process. Internal to the auditory capsule, is a large depression, corresponding to the foramina lacera anterius and posterius.

Just posterior to the foramina lacera, and internal to the base of the para-mastoid

process, is the anterior condyloid foramen, and anterior to the former, just external to the root of the pterygoid processes, is the foramen ovale.

The glenoid surface is one of the most important features of the skull in reference to the habits of the animal. It is broad, and relatively flat, as in existing Ruminants. Posteriorly, it is bounded by a relatively, very large, post-glenoid tubercle, which is transversely compressed conoidal, and more prominent inferiorly than the auditory capsule. The anterior two-thirds of the glenoid surface is slightly convex, and directed more forward than in the Deer. Internally, it possesses great extent, and is continuous with a large surface of origin for the pterygoid muscles. At the base of the post-glenoid tubercle, the surface is slightly concave, and at its external part, is directed a little more outwards than in the Deer.

The pterygoid processes, with the vertical plates of the palate bones, are very much more prolonged than in the Deer, and are stronger, especially at the borders of the palatine notch. The latter is narrow, and extends as far forward as the posterior third of the last molar tooth. The posterior palatine foramina are situated in the plates of the superior maxillary bones, anterior to the position of the true molars, and usually on a line with the fourth premolar. The two sides of the hard palate have more or less disposition to incline towards each other about the centre, in some cases being much depressed in this position, but in others not so much so.

The position of the incisive foramina cannot be exactly ascertained, but they appear to exist on a transverse line with the canine teeth.

Orbits.—The inner wall of the orbit is but slightly concave compared to that of the Deer, and at the inner canthus is bounded by a compressed mammillary, lachrymal process. Within the latter are two unequal lachrymal foramina.

Between the floor of the orbit and the lachrymal bone above, is a large, transversely oval foramen: the entrance of the infra-orbital canal.

The spheno-orbital foramen, including the homologue of the foramen rotundum, is large, and vertically oval, and is situated just within the anterior angular termination of the surface of origin for the pterygoid muscles.

The foramen ovale is placed a short distance in advance of the os petrosa, to the outside of the commencement of the pterygoid process, and is almost half the size of the preceding foramen.

Relations of the Bones of the Skull.—The occipital bone posteriorly is trilateral, with a broad, prominent apex, as in the Camel.

The lambdoidal suture ascends from the base of the para-mastoid process backwards between the occipital and posterior process of the pars petrosa, to the summit of the latter, when it advances on the side to the top of the skull, between the pars squamosa, parietal, and occipital bones.

The parietal bones form but a single piece, and are remarkable, as in the Camel, on account of their relatively very great length, when compared to those of other recent Ruminants. They are narrowest posteriorly, and are prolonged on each side downwards in advance of the pars squamosa, to join the wing of the post-sphenoid. Anteriorly, they are deeply notched for the reception of the posterior extremities of the frontals.

The latter remain separated throughout life, and relatively to those of most recent Ruminants, are very short.

The nasal bones are of nearly uniform breadth, and posteriorly are received in a deep angular notch of the frontals.

The palate plates of the palate bones advance as far as a line transverse to the first true molars, or even a little anterior to them.

The intermaxillary bone is very much shorter than that of existing Ruminants, or even that of Carnivora, to which it has a strong resemblance at its lower part. Its process upwards is short, and is received by the apex into a notch of the superior maxillary bone, and, so far as can be ascertained in the specimens, does not come in contact with the nasal bone.

Inferior maxilla.—(Tab. x., fig. 5.) The lower jaw of Oreodon resembles more that of the Hog in its general form than of any of the existing Ruminants, excepting that the canine and incisive alveoli retain an upward direction like the molars.

The body of the lower jaw is relatively deeper than in the Deer, and its base is more nearly straight. Its outer side is vertical, and very slightly convex. Anterior to the mental foramen, which is placed just below the second premolar, or the interval between it and the first, it rapidly converges to the symphysis. The latter is deep, and forms a strong slope, but approaches the vertical line even more than in the Hog.

The alveolar margin ascends so rapidly posterior to the fourth premolar, that the body of the jaw behind the last true molar is more than half as deep again as it is below the former tooth.

The ramus is very broad, and vertical externally. At its upper part, below the post-coronoid notch, it is deeply depressed relatively to the condition of the same part in existing Ruminants.

The posterior margin of the lower jaw, a short distance below the condyle, in conjunction with the angle and bottom of the ramus forms a thick, strong convexity, prominent backwards and downwards, and also elevated externally for the attachment of the masseter muscle.

The coronoid process is almost as short as in the Hog, and the condyle has the same relative position to its base as in the latter animal.

Dentition.—The formula of the permanent dentition of Oreodon is,—in. $\frac{3,3}{4,4}$, can. $\frac{1,1}{1,1}$, premol. $\frac{4,4}{3,3}$, mol. $\frac{3,3}{3,3}$, $= 44$.

The superior molar teeth (Tab. x., 4, 5; xi., 2, 3) on each side, internally, are nearly parallel. They form a continuous row, and are separated from the canines by a hiatus, not greater than the antero-posterior diameter of the first premolar, for accommodating the inferior canine.

Laterally the superior incisors are in contact with the canines, but in some cases are separated by a slight hiatus. They project vertically downwards, and are arranged in the tangent of a considerably greater circle than that of the Wolf.

The inferior molars are also very nearly parallel on both sides. They form a continuous row, with the canine included. Anterior to the latter, between it and the incisors, is a hiatus for accommodating the superior canine, but less in size even than that behind the last-mentioned tooth.

The inferior incisors are oblique in their direction, but relatively not quite so much so as in the Musk-deer, and on both sides they are arranged in the tangent of a smaller circle than the upper ones.

The true molars in both jaws have the same relation to one another as in the Deer.

The first premolar of the upper jaw has its posterior margin a little external to the contiguous margin of the succeeding tooth, as if it had been pushed outwards and backwards, in a jaw where but little space could be lost, to make the hiatus between it and the canine.

In the same manner, in the lower jaw, the latter tooth and the first premolar appear pushed a little outwards and backwards in their relation to each other and the succeding molar, so as to allow the formation of the hiatus anterior to the canine.

The crowns of the superior true molars are composed of four simple, pointed, symmetrical, pyramidal lobes, as in Merycopotamus. In comparison with existing Ruminants their form is most like those of the Deer, but they are more expanded, and consequently are relatively of greater transverse breadth, more square, and the interlobular depressions are more shallow.

The outer lobes are not separated from one another as in Merycopotamus, but are connected by a prominent buttress projecting externally, as in Anthracotherium. The remaining anterior and posterior margins of the outer lobes are also prominent externally, and with the exception of the posterior margin of the postero-external lobe of the first and second teeth, form buttresses nearly or quite as large as the middle one. The buttresses are laterally compressed, and expand towards their base, where they become confluent by means of a basal ridge passing between them. The latter ridge is sometimes obsolete, especially at the base of the postero-external lobes of the posterior two molars.

The external faces of the outer lobes are concave from side to side, slightly prominent in the middle line, and incline at an angle of about 40°. The internal faces are nearly vertical, but incline slightly outwards, and are angularly convex.

The external faces of the inner lobes are concave, and have the same degree of inclination as the corresponding faces of the outer lobes. The internal faces are convex, and less angular than those of the outer lobes.

The summits of the lobes are crescentic ridges elevated into a point at their middle. The extremities of the outer crescents rest upon the external buttresses. The anterior extremity of the antero-internal crescent, and the posterior of the postero-internal crescent, are continuous with a short ridge descending to the summit of the corresponding buttresses of the outer lobes. The anterior horn of the postero-internal crescent ends abruptly between the postero-external lobe, and the posterior horn of the antero-internal crescent, which also terminates abruptly, but is bent forward and ceases short of the posterior portion of the inner face of the antero-external lobe.

A basal ridge exists anteriorly and posteriorly upon the internal lobes, sometimes continuous internally at the base of the postero-internal lobe of the second and

third molars, more frequently in the latter only than in both. Between the internal lobes the ridges occasionally conjoin and form a common intervening tubercle.

When the enamel summits of the lobes of the true molars are worn off, the exposed dentinal surface of the outer lobes presents the form of W, or two crescents continuous, that of the inner lobes of two distinct crescents.

The crown of the fourth premolar is composed of two pyramidal lobes, like those of the true molars but much larger.

The crowns of the anterior three premolars are single, three-sided pyramids with a pointed apex decreasing in size from the third to the first, and nearly alike in their details. Their outer face is broad and condiform, less concave and more vertical than in the succeeding teeth. The two inner sides are separated by a prominent angle in the middle line.

The postero-internal face is excavated into a broad cul-de-sac, the antero-internal face into two smaller culs-de-sac.

The true molars are implanted by four roots, the third and fourth premolars by three roots; two external and one internal, and the anterior two premolars each by two roots.

The inferior true molars (Tab. x., fig. 5; xiii., 3–6) have nearly the same size and form of those of Cervus Virginianus. The outer lobes are less oblique in their relative position to one another than in the Deer, and are broader at base externally, but become more tapering towards the apex. Their inner face is concave, and much more shallow than in the Deer, but gains in breadth what it loses in depth. The crescentic summits of the outer lobes of each tooth at their contiguous extremities, become continuous.

Anteriorly and posteriorly the true molars possess a basal ridge, and between the outer lobes of each tooth the latter constitutes a broad pyramidal heel.

The internal faces of the inner lobes present three folds, as in the Deer, but the posterior marginal fold is shorter, thicker, and more divergent backward from the base.

The fifth lobe of the posterior molar is more simple in form, and more distinct from the adjoining lobes than in the Deer. In transverse section it is a broad ellipse, and has an acute U-shaped summit.

In the attrition to which the true molars are subjected, the acute enamelled summits of the pyramidal lobes soon give way to crescentic surfaces of exposed dentinal substance, which gradually increase in breadth, or the crowns are worn down, until finally the whole enamelled triturating surface is obliterated. The crowns of the inferior three premolars are quite peculiar in their form. Exteriorly they bear considerable resemblance to those of the Deer, but do not exhibit the deep vertical depression so conspicuous in the teeth of the latter. Internally, they are much less complex than in the animal just mentioned.

Each premolar is constituted principally by a single broad pyramidal lobe, very much longer than that of the true molars. The anterior portion of their outer side is continuous obliquely inwards, so as to bring the anterior margin within the position of the preceding tooth posteriorly. The summit separating the outer from the inner side, is an acute ridge rising to a point.

The middle portion of the inner side of the third premolar is constituted by a pyramidal process, nearly as high as the apex of the principal lobe, with which it is continuous. Posteriorly, the inner side of this tooth has a quadrilateral cul-de-sac, bounded internally by a short pyramidal tubercle. The surface of the anterior portion of the inner side is depressed.

The second premolar internally presents a ridge descending from its apex a little backwards, and expanding along the base of the crown. Anteriorly and posteriorly to the ridge, the surface is depressed, and the ridge sends an offset backwards, which terminates abruptly about the centre of the posterior depression.

The first premolar presents a ridge similar to that existing in the second, but much less developed, and without the posterior offset.

The inferior molars are inserted by two roots, except the last, which has three, like in existing Ruminants.

The canine teeth of Oreodon are quite peculiar in form, and are about the same length in both jaws.

The superior canines curve forward, downward, and in a less degree outward. Those of the male are a little more robust, and are directed more externally than in the female. Their crown is a trihedral pyramid, with acute margins and a pointed summit. The sides are nearly equal, being posterior, antero-internal, and external, and are smooth. The posterior side is opposed to the anterior margin of the corresponding tooth below.

The inferior canines are straight, occupy a position posterior to those above, and take a course obliquely upwards, forwards, and outwards. The crown is a broad, transversely compressed pyramid, with an inner and outer convex side; an anterior trenchant margin, opposed to the posterior surface of the canine above, a posterior trenchant margin, and a pointed summit.

Of the three superior incisors on each side, the internal is the smallest, the other two being nearly equal in size. The outer face of their crowns is convex, and nearly ovoid in outline.

Of the inferior incisors, the internal of each side is also the smallest; the succeeding two are nearly equal in size, and the lateral, or fourth incisor, is a fifth larger than those last mentioned. The outer face of the three mid incisors is convex and oblong quadrilateral; and that of the fourth incisor is also convex, but is more trapezoidal in its form.

Temporary dentition.—The deciduous teeth of Oreodon, so far as can be ascertained, are as follow: in. $\frac{?}{?}$ can. $\frac{1-1}{1-1}$ p. m. $\frac{2-2}{2-2}$ m. $\frac{1-1}{1-1}$.

The first permanent premolar of the upper jaw appears to have no temporary predecessor. The superior true deciduous molar is exactly like the permanent true molars in form, and is about one-sixth smaller.

The crown of the second premolar is composed of three pyramidal lobes; two posterior and transverse, the other anterior and opposite the former.

The first premolar in form is very nearly like its successor.

In the lower jaw, the deciduous true molar has six pyramidal lobes in three transverse pairs, as in existing Ruminants, etc., and the true premolars have the same form as their permanent successors.

SPECIES OF OREODON.

OREODON CULBERTSONII. *Leidy.*

(Tab. x., figs. 4, 5, 6; xiii., figs. 3, 4.)

Merycoidodon Culbertsonii: Proc. Acad. Nat. Sci., vol. iv. p. 47; pl. figs. 1–5.
Oreodon priscus: ib., vol. v. p. 238.
Cotylops speciosa, ib., p. 239.

Of this species, the head of which is about the size of that of the Newfoundland dog, there are the following specimens in the collection of Dr. Owen.

1. A nearly entire head, wanting only the end of the nose, incisors and their alveoli, upper canines, the right zygoma and post-orbital arch, a small portion of the left zygoma, the posterior two-thirds of the sagital crest, and the angle of the right side of the lower jaw, to be complete. (Tab. x., 5, 6.) From its relation of size with the specimen next designated, it is presumed to be the head of a female.

ADMEASUREMENTS.*

	Lines.
Breadth of face at infra-orbitar foramina,	18¼
" " above first premolars,	15
Height of face from infra-orbitar foramina to ends of anterior angular processes of os frontis,	16
Breadth of nasal bones at the ends of the latter processes,	8¾
Length of series of superior molars,	40½
" " inferior "	40
" " superior true molars,	22
" " inferior " "	24½

2. A skull (Tab. x., 4), accompanied by a small fragment (Tab. xiii., 4) of the right side of the lower jaw, containing the three true molars broken. The former has the end of the nose, zygomæ, and occipito-sagital protuberance broken away. The forehead is somewhat crushed, but otherwise, excepting fractures, without displacement of fragments, the specimen is pretty perfect. It contains all the molar teeth of both sides, the left canine, and the root of the right.

From the greater degree of robustness of this specimen, compared with that indicated in Number 1, it is presumed to be of a male individual.

The face is more flattened above, and its transverse section has a more square appearance than in the female.

The molar teeth are more robust than in the latter, and the canines are also more robust and project more outwardly.

* A short table of admeasurements is appended to the description of each specimen, so as to present the extent of variation in size in different individuals of the species.

ADMEASUREMENTS.

	Lines.
Breadth of face at the infra-orbitar foramina, ...	19½
" " above first premolars, ...	19½
Height of face from infra-orbitar foramina to angular processes of os frontis,	16
Breadth of nasal bones at latter processes, ...	10
Length of series of superior molars, ...	43½
" " true "	23½

3. A face, apparently of a male, containing all the molars of both sides, except the first premolar.

ADMEASUREMENTS.

	Lines.
Breadth of face at infra-orbitar foramina, ...	19½
" " above first premolar, ...	19½
Height of face from infra-orbitar foramina to angular processes of os frontis,	14
Length of series of molars, ...	41

4. A fragment of a face and forehead.

ADMEASUREMENTS.

	Lines.
Breadth of face at infra-orbitar foramina, ...	17½
" " first premolar, ...	16¾
Height from infra-orbitar foramina to anterior angular processes of os frontis,	12½
Breadth of nasal bones at the latter processes, ...	11

5. A fragment of a face and forehead of an individual just reaching adult age, containing on one side the permanent true molars protruded, and fragments of the second and third permanent premolars, which were just on the point of eruption.

6. A fragment of the face of a young animal containing on both sides portions of the temporary molars, the two succeeding permanent true molars fully protruded, and the last true molars concealed within the jaw.

7. The greater portion of a face and lower jaw, containing all the molars except one.

ADMEASUREMENTS.

	Lines.
Breadth of face at infra-orbitar foramina, ...	20
Height " " " " to angular processes of os frontis,	16
Length of series of superior molars, ...	20
" " inferior "	22

8. A head of a young animal, with the right side of the lower jaw and angle of the left, the zygoma, end of the nose and right superficial portion of the face, broken away. The right upper and the left lower jaw contain all the molars nearly perfect, consisting, in the former, of the first permanent (?) premolar,

the deciduous molars, and the succeeding two permanent true molars, fully protruded, and the last yet concealed within the jaw; in the latter, the deciduous and permanent true molars, except the last, which had not yet protruded, form the series.

9. An inferior canine tooth with the anterior half of its crown worn down.

10. Nine fragments of upper and lower jaws of eight different individuals, containing true molars.

ADMEASUREMENTS OF THE HEAD OF OREODON CULBERTSONII.

	Lines.
Estimated length of the male head, from the occipital condyles to the incisive alveoli,	93
Estimated length of female head,	88
Greatest breadth of head at the zygomæ,	50
Breadth at infra-orbitar foramina,	19
Estimated length of sagittal crest,	34
Length of upper molar series,	40
" lower " "	39

OREODON GRACILIS. *Leidy.*

(Tab. xi., figs. 2, 3; Tab. xiii., figs. 5, 6.)

Oreodon gracilis, Proc. Acad. Nat. Sci. of Philad., vol. v., p. 239. Merycoidodon gracilis, (*Syn.*)

This species was characterized first in a verbal communication to the Academy of Natural Sciences, in 1851.

It is relatively small, the head being about the size of that of the Red Fox.

In Dr. Owen's collection are contained the following specimens of O. gracilis.

1. A cranium and face, with the base of the former and the nasal extremity of the latter broken away. The specimen contains the true molars and the last premolar entire upon the right side, and fragments of all the others. (Tab. xi., 2, 3.)

2. A fragment of a face, containing on the left side the posterior two true molars. It agrees with the corresponding portion of Number 1.

3. The head of a young individual, with the posterior and upper portions of the cranium, nose, and left side of the lower jaw broken away. The deciduous molars had not been shed, and the last true molar remains entirely concealed within the jaw.

Comparison of Oreodon Culbertsonii and O. gracilis.—Besides the great disproportion in size of the two species, there are a few other differences to be indicated.

In O. Culbertsonii the sagittal crest rises in a pyramidal manner gradually from the sides of the temporal fossæ, but in O. gracilis, appears only as an abruptly elevated roughened line at the conjunction of the parietal bones. The posterior extremities of the nasal bones are angular in the former, but convex in the latter. The lachrymal depression is not quite so deep relatively in O. gracilis as in O. Culbertsonii, and the orbital entrance is more nearly circular in that than in this.

The ossa tympanica are also more inflated in O. gracilis.

Upon the teeth of the latter the enamel is thinner relatively upon the external concave faces of the inner lobes of the upper molars, and the internal faces of the outer lobes of the lower molars than in O. Culbertsonii.

ADMEASUREMENTS OF THE HEAD OF O. GRACILIS.

	Lines.
Estimated length from the summit of the inion to the incisive alveoli,	56
Breadth at the maxillo-malar suture below the orbits,	29
Breadth at infra-orbitar foramina,	12
Estimated length of sagital crest,	22
Length of upper molar series,	25
" lower " "	25½

PALÆOTHERIUM. *Cuvier.*

PALÆOTHERIUM (?) PROUTII. *Owen, Norwood,* and *Evans.**

(Tab. ix., figs. 3, 3 a; Tab. xii. B, figs. 3, 4, 6, 7, 8.)

In the American Journal of Science for 1847, Dr. H. A. Prout has given a description of a fragment of the lower jaw of an enormous Pachyderm, suspected to be a species of Palæotherium. The specimen was the first of the many mammalian remains, which have been brought to the notice of the scientific world from the vast Eocene cemetery of Nebraska.

In Dr. Owen's collection is a fragment of the left side of a lower jaw (Tab. ix., fig. 3 *a*), apparently of the same animal, but of a smaller individual. It is very friable, and originally, i. e., after the death of the animal, was very much compressed and fractured from pressure. The fragment is sixteen inches long, and contains the true molars and portions of the fangs of the two preceding premolars. Along the line of the true molars, the jaw measures nine and a half inches, and below the last molar posteriorly is six inches in depth.

There are also in the same collection the crown of a molar, apparently an inferior third premolar (Tab. xii. B, 7), an inferior canine (8), and a fragment of an upper molar (6), which I suspect belonged to the same individual as the portion of lower jaw.

Besides these the collection contains a left last lower molar (Tab. ix., 3), a right lower penultimate molar, of two other individuals of the same species, and two fragments of upper molars (Tab. xii. B, 3, 4), probably of the latter. The inferior true molars resemble those of Palæotherium in their form, but more particularly those of Anchitherium, in having no trace of a basal ridge internally. The crowns are worn upon the triturating surface into crescentic spaces, from the inner margin of which the sides do not shelve downwards in a convergent manner to the base of the teeth, as in Palæotherium; but the horns of the crescents enclose broad con-

* Proc. Acad. Nat. Sci., v. 66.

cavities, bounded internally by a thick, obtuse ridge, descending from the elevated ends of the crescents. The basal ridge externally is well developed, and is less deep at the intervals than at the middle of the lobes.

The third lobe of the last lower molar (Tab. ix., fig. 3) has a thick, acute ridge, bounding the cavity upon the inner side of the triturating surface.

The molars undergo a rapid reduction in size anteriorly, for the last molar measures a little over four inches antero-posteriorly, the first true molar twenty-two lines, and the third premolar only seventeen lines.

The latter tooth (Tab. xii., B, 7), presents the same form as the true molars.

The crown of the inferior canine (Tab. xii. B, 8) is curved conoidal, nineteen lines long, and one inch broad at the base. It presents a strongly developed basal ridge internally, which has a feeble disposition to continue externally. The tip of the crown and its antero-external side for half an inch in the specimen have the enamel worn off.

The fragment of an upper molar (Tab. xii., B, 6), considered to belong to the same individual as the portion of lower jaw, consists of a conical protuberance of the inner side of the grinding surface. The remaining fragments of upper molars are single outer lobes. These are deeply concave externally, as in Palæotherium magnum, and have a narrow basal ridge. (Tab. xii., B, 3, 4.)

All the preceding specimens, except, probably, the latter two, I suspect belong to a different genus from either Palæotherium or Anchitherium, and should the suspicion prove correct, Titanotherium would be a good name for the animal, as expressive of its very great size.

RHINOCEROS.

Two species of Rhinoceros are indicated as having existed in the ancient fauna of Nebraska, by its fossil remains. One was about three-fifths the size of the existing Rhinoceros Indicus, and the other was very small, not being a great deal larger than the common Hog.

Both species have been characterized in the Proceedings of the Academy of Natural Sciences, the former under the name of Rhinoceros occidentalis, the latter with that of R. Nebrascensis.

RHINOCEROS OCCIDENTALIS. *Leidy.*

(Tab. ix., figs. 1, 2.)

Rhinoceros occidentalis: Proc. Acad. Nat. Sci., vol. v., p. 119; ib., 276.
Acerotherium occidentale: ib., p. 331.

The species was at first established upon several fragments of teeth, and afterwards confirmed by obtaining several entire teeth.

In the collection of Dr. Owen are contained of R. occidentalis the following specimens:

1. A mutilated skull, with one series of molar teeth entire.
2. Two fragments of lower jaws of different individuals.
3. The distal extremity of an os femoris.

Description of the Skull.—The specimen of the skull is very much fractured, but those parts which are remaining still retain their original position. It has lost almost the entire superficies of the right side, the end of the nose, occiput, excepting its lower portion, and the outer portions of the molar teeth of the right side. It belonged to an adult but not old animal, as the permanent teeth are all protruded, but none of the characteristic grinding surfaces are effaced.

Lateral view.—The side view of the skull presents its most remarkable feature in a striking manner, which is its great degree of straightness antero-posteriorly, when compared with other species. It has the appearance as if a head of the ordinary form of the recent Rhinoceros had been bent downwards anteriorly and posteriorly until it had become nearly horizontal. With a depressed condition of the back part of the skull, a relatively large portion of the temporal fossa is situated posterior to the root of the zygoma.

The upper surface of the latter inclines forwards at an angle only of 15°, and the zygoma itself is rather more sigmoid in its course forwards than in Rhinoceros Indicus, and its outer surface is deep, being nearly two inches, and is moderately convex and nearly vertical.

The temporal fossa has about the same relative extent as in R. Indicus, but is longer and has less vertical depth. Superiorly it is defined by a prominent margin commencing at the post-orbitar process, and coming in contact with that of the opposite side at the posterior part of its course, forming a double parietal crest. The surface of the fossa is very oblique, but for two and a half inches above the root of the zygoma, is convex and nearly vertical.

The orbit is more transversely and deeply excavated, and its orifice is better defined than in R. Indicus.

The supra-orbitar process is large, prominent, convex, and rough, and partially overhangs the inferior margin of the orbit.

The face is relatively longer than in R. Indicus, and therefore very much more so than in Acerotherium incisivum.

From a fragment of the left intermaxillary bone remaining in the specimen, it may be determined to be large and strong, but the notch of the anterior nares is relatively small.

The maxillo-intermaxillary suture is strongly serrate, and reaches within a half inch of the naso-maxillary suture.

Superior view.—The upper surface of the head is remarkable on account of its great breadth at the forehead, and its narrowness posteriorly. It is a slightly depressed plane, prominent at the posterior extremity, as constituted by the double parietal crest, but is most elevated above the forepart of the orbits.

The upper surfaces of the nasal bones incline towards each other in the specimen,

probably more than natural, for they are fractured from their connexions, although there appears to be but little displacement.

There is no roughness or elevation upon the forehead, or rise forwards upon the nose, as far as the position of the second molar tooth, indicating the possession of a horn by the animal, and it therefore probably belongs to the subgenus Acerotherium, *Kaup*, although the face, instead of being decreased in length, as in the latter in its relation with the true Rhinoceros, is even increased, as before stated.

Posterior view.—The back part of the head is too much broken to gain much information in the details of its character. It appears to have been relatively narrow, but very much bulging posteriorly, so that the portion forming the upper boundary of the foramen magnum overhangs the latter considerably posterior to its inferior margin.

Inferior view.—(Tab. ix., fig. 1.) In the specimen the right condyle of the occiput and the lower internal portion of the left are broken away, but in the remainder of the latter it is very perceptible that the condyles have a much more vertical position than in R. Indicus.

The basilar process is narrow, the distance between the anterior condyloid foramina being only one inch.

The foramen ovale is distinct from the foramen lacerum, and is placed on a line just in advance of the post-glenoid tubercle.

The latter is relatively short and broad in comparison with that of R. Indicus.

The glenoidal surface is relatively greater antero-posteriorly in comparison with its breadth than in the species last mentioned. It also presents a little more outward, and at its most external posterior portion is more depressed.

The hard palate in the specimen is considerably fractured, but all the parts appear to have remained perfectly in position. It is very narrow and very much arched, especially anteriorly. The teeth in a nearly straight line upon each side converge anteriorly, being distant between the anterior lobes of the last molars twenty-two lines, and between the first of the series only nine lines.

Inferior maxilla.—Of the two fragments of the lower jaw in the collection of Dr. Owen, one broken into two of the left side, contains the posterior two molars, and part of the one preceding, the other fragment, also, of the left side contains the third to the fifth tooth inclusive. Both belonged to adult individuals, but the only anatomical characters to be gained from the fragments, exclusive of the teeth, are the depth of the lower jaw, which is twenty-eight lines below the last molar, and the thickness, which is fourteen lines.

Dentition.—The superior molars (Tab. ix., fig. 1) are about one-third smaller than those of Acerotherium incisivum, and also bear considerable resemblance to them in their form.

They all possess a basal cingulum, which is, however, but feebly developed on the outer side of the anterior half of the fifth and sixth molars, and is obsolete on part of the internal lobes of the same teeth. Upon the premolars, from the second to the fourth inclusive, the basal ridge is very strongly developed.

The posterior molar, as in Acerotherium incisivum, exhibits no tendency to form a

posterior valley. Its principal valley is intruded upon only by a slight bulge at the middle of the antero-internal lobe.

In the corresponding lobe to the latter in the preceding two molars, the bulging posteriorly successively increases, and also exists anteriorly. This dilatation of the antero-internal lobes decreases the depth externally of the anterior valleys, so that they slope downwards from their entrance, and in the trituration of the teeth they are obliterated from without inwards, leaving no islets of enamel behind as in the premolars.

In the specimen under consideration, the abrasion of the first true molar has effaced the outer half of the anterior valley.

In the second to the fourth premolars inclusive, the inner lobes are confluent internally at their bases, but to a less extent in the anterior than the remaining two of those designated. From trituration, the latter in the specimen exhibit the remains of the anterior valleys as simple trilateral pits of enamel occupying the centre of a broad space of dentine, while in the former the anterior valley still continues open internally. The posterior valleys of the posterior three premolars are as deep externally as the corresponding portion of the anterior valleys. The basal ridge of the three teeth just designated, envelopes the base of the postero-internal lobes to a much greater extent than upon the preceding lobes, and in the specimen under observation the first premolar presents an almost equilateral triangular triturating surface, possessing both internal lobes in a rudimentary state. Constituent portions of the basal ridge connect the bases of the lobes together. The short anterior valley remains open internally, but the external extremity only of the posterior exists as a small trilateral pit of enamel.

Inferior molars.—(Tab. ix., fig. 2.) The teeth preserved in the fragments of lower jaws referred to belong all to the posterior four molars, and these do not differ in their form from those corresponding to them in recent species of Rhinoceros.

A basal ridge exists in all, but is obsolete on the inner side of the posterior three molars and the outside of the hinder lobe of the same teeth, except the last.

ADMEASUREMENTS.

	Inches.
Length from occipital condyle to first premolar,	$14\frac{3}{4}$
Distance from end of post-glenoid tubercle to parietal crest,	6
Height of face from alveolar border to supra-orbitar prominence,	$5\frac{1}{2}$
Distance from occipital condyle to anterior margin of orbit,	$10\frac{3}{4}$
Breadth of skull at zygoma,	$8\frac{3}{4}$
" of forehead at supra-orbitar protuberances,	7
Length of upper molar series,	$7\frac{1}{4}$

RHINOCEROS NEBRASCENSIS. *Leidy.*

(Tab. xii. A, fig. 6; Tab. xii. B, fig. 5.)

Rhinoceros Nebrascensis: Proc. Acad. Nat. Sci., vol. v., p. 121.
Acerotherium Nebrascense: ib., p. 331.

This species was first established upon the anterior portion of a skull and lower jaw, containing all the molar teeth of an old individual belonging to the collection of the Smithsonian Institution.

In Dr. Owen's collection is a head of the same species, of a very old individual, with the upper part the whole length broken away. It contains all the molars nearly perfect, which, however, have the crowns worn nearly to the edge of the alveoli.

There is also in the same collection a face, very much mutilated, except the forehead, of an individual which had just reached adult age. It contains all the molars nearly perfect; the last one about two-thirds protruded.

Besides the foregoing, there are several small fragments of upper and lower jaws, as follows:

1. A portion of an upper jaw, containing the first permanent true molar, slightly worn, and a fragment of the fourth permanent premolar still concealed within the jaw.
2. A posterior fragment of a lower jaw containing the last three molars.
3. A fragment of a lower jaw of a very young animal, containing the posterior temporary molar, and the first permanent true molar, both unworn.

Description of the head.—In the lateral view, Rhinoceros Nebrascensis presents most of the peculiarities of Rhinoceros occidentalis.

The root of the zygoma is implanted at the lower part of the middle of the temporal fossa. The surface of the latter is convex, and relatively smooth.

The orbit has nearly the same form as in Rhinoceros occidentalis, but its floor is more superficial. Its entrance is well defined, as in the latter species, but the supra-orbitar process is not quite so prominent nor so rough. The post-orbital process is distinct. At the inner canthus is a short lachrymal process, and internal to this two lachrymal foramina, one above the other.

The face, as constituted by the alveoli for the superior molars, is vertical; above this it appears to have been oblique, but it is too much broken in the specimens to judge accurately of its form.

The infra-orbital foramen is placed about an inch above the interval of the second and third premolar.

The malar bone is directed rather more outwardly than in Rhinoceros occidentalis, and its external face presents more upwards.

The forehead is broad, elevated, and convex above the orbits, but depressed and concave in the middle. The ridges upon the frontal bone which define the temporal fossa antero-superiorly, curve rapidly inwards from the post-orbital processes,

and in the specimen in which the forehead is preserved, an inch behind their commencement, they are within five lines of each other, so that they no doubt joined to form a parietal crest, the superior boundary of the temporal fossæ.

The occipital surface is much more trilateral than in Rhinoceros Indicus, and is relatively narrow, but bulges in the middle so that its extent of surface is really not reduced.

The foramen magnum occipitis is subrotund, about ten lines in diameter. Its margin above is notched, and overhangs considerably posterior to the inferior margin, so that the foramen is directed more downwards than in R. Indicus. The occipital condyles are more vertical than in the latter.

The mastoid process forms the posterior boundary of an inverted U-shaped passage to the tympanum, and projects inferiorly nearly as much as the post-glenoid tubercle. The latter relatively to that of Rhinoceros Indicus, is very short, being only ten lines. It is, however, broad and robust and truncated at its extremity. The glenoid surface upon the root of the zygoma is directed rather more outwards and backwards than in R. Indicus, but upon the post-glenoid tubercle is depressed and directed forward with a slight inclination outwards.

The post-glenoid tubercle is relatively to that of Rhinoceros Indicus very short, but is broad and robust, and truncated at its extremity.

Inferior maxilla.—The body of the lower jaw is vertically convex, and its base more convex antero-posteriorly than in Acerotherium incisivum. The ramus is much depressed internally, and is thin. The posterior maxillary foramen is situated about an inch posterior to the last tooth.

Dentition.—The permanent teeth remain until a late period of life without any reduction of their number, except the normal first of the lower jaw, as illustrated in the skull containing on both sides all the molars, seven in number, worn down nearly to the edge of the alveoli. The formula for the molars is $\frac{7}{6}$.

The upper teeth (Tab. xii. A, fig. 6), bear very great resemblance to those of Acerotherium incisivum. They all possess a basal cingulum, well developed all round, when not obliterated by pressure where the teeth are in contact with one another, except at the inner side of the bases of the internal lobes of the posterior three molars.

The last molar exhibits a tendency to the formation of a posterior valley by the presence of a deep vertical depression at its posterior angle. The bottom of the principal valley is nearly level, and nearly as deep as the crown; and at its entrance is bounded by a mammillary eminence, a constituent portion of the basal ridge. The internal lobes are simple; the anterior is slightly expanded at its middle posteriorly.

The preceding two molars have their inner lobes directed in a slightly sigmoid course, inwards and backwards. These lobes are simple, expanded at base and internally, and rapidly taper towards their summit. The anterior lobes are dilated at their middle posteriorly, increasing in this disposition successively from the last to the fifth molar. The anterior valley of the fifth and sixth molars is broad, and decreases in depth from the entrance outwards, so that in the attrition to which

these teeth are subjected, the anterior valleys commence to be obliterated from their termination.

In the second to the fourth molars inclusive, the anterior of the inner lobes is the larger, and all the latter become dilated just before their termination, and confluent from their bases, most so in the third molar, and least in the fourth. The anterior and posterior valleys are nearly of the same depth at their termination externally, except in the fourth premolar, in which the posterior valley is more shallow. The basal ridge of these teeth is well developed all round, envelopes the base of the postero-internal lobe to twice the extent it does that in advance, and from its great vertical extent posteriorly adds very much to the depth of the posterior valley.

The first molar still retains the two internal lobes, of which the posterior is very distinct, but the anterior is reduced to the condition of a tubercle rising out of the basal ridge, and connected by a transverse lamina with the internal side of the outer portion of the tooth.

The inferior molars (Tab. xii. B, 5; xv. 3), six in number on each side, closely resemble those of Acerotherium incisivum. They possess a basal cingulum developed all round. The first of the series in the outline of a transverse section forms an isosceles triangle, but like all the others, it is constituted of two lobes, of which the anterior is so compressed laterally as almost wholly to lose its crescentic appearance.

ADMEASUREMENTS.

	Inches.	Lines.
Length from occipital condyle to anterior part of first molar, .	9	2
Greatest breadth at zygomæ, ...	5	9
Breadth at infra-orbitar foramina, ...	2	3
" just above root of zygomæ, ...	2	8
Length of molar series, ...	4	6
Antero-posterior diameter of the sixth upper molar, . .		11
Transverse " " " " " . .		11
Antero-posterior diameter of the fifth lower molar, . . .		10½
Transverse " " " " " . . .		6

ARCHÆOTHERIUM. *Leidy.*

(Tab. x., figs. 1, 2, 3; Tab. xi., fig. 1.)

Archæotherium Mortoni, *Leidy:* Pr. Ac. N. S., vol. v., p. 92.

This remarkable Pachyderm, judging from the form of its teeth, is closely allied to the Chœropotamus, *Cuvier*, and the Hyracotherium, *R. Owen.*

The species was first indicated by a fragment of the face containing the posterior two premolars of the left side. In Dr. Owen's collection is a more characteristic specimen, consisting of the middle portion of the face, much mutilated, of A. Mortoni. This fossil contains the first and second true molars on both sides entire, excepting the former of the right side, which has a portion broken off. It also possesses the alveoli still retaining the fangs of the last molars, and also those for the last premolars, and a portion of those in advance.

The crowns of the first and second true molars (Tab. xi., fig. 1) differ most strikingly from those of the corresponding teeth of Hyracotherium, in not possessing a continuous ridge around the base, and from those of Chœropotamus in the total absence of a basal ridge on the inner side.

The crowns of the teeth just alluded to of Archæotherium, are quadrilateral, nearly cuboidal. The triturating surfaces anteriorly project into a remarkably prominent basal ridge or platform one line thick, and three lines deep below the commencement of the enamel. Posterior to this ridge the crown is elevated into six mammillary eminences placed in two transverse rows a little convex forwards from the middle, and smaller ones being placed in a trifling degree in advance of the others. The postero-internal cone is continuous from its apex with an oblique prominent ridge descending to the base of the postero-external cone posteriorly. On the outside of the crown is a slight oblique ridge connecting the bases of the external cones. The apices of all the latter, which are unworn, exhibit an excavation relatively slight to that of Hyracotherium.

The enamel where the original surface is preserved is thick and rugose. Upon the second molar it is slightly worn, but upon the triturating surface of the first has in greater part become very thin, and at the summits of the cones, excepting the postero-external and internal, is completely removed, so as to present lenticular-shaped surfaces of dentine.

The crown of the posterior molar, judging from the base of connexion with the fangs still remaining, was also quadrilateral, but the outside inclined backward and inward as in Rhinoceros, and the posterior side was relatively small.

The fragment alluded to containing two premolars, belonged to an older individual than the preceding, and consequently the teeth are more worn.

The last premolar has a quadrilateral crown, the inner side being the shortest, and is convex. Posteriorly it possesses a prominent basal platform continuous with a very slight ridge postero-externally. Antero-externally there is also a slight ridge, which was probably continued anteriorly, but is worn away. The triturating surface is worn off to a transversely ellipsoidal disk of dentine, margined by enamel, and continuous, by a short isthmus on the anterior side of the tooth, with a second and smaller transversely ellipsoidal surface just over the antero-external fang.

The premolar in advance is compressed, conoidal, convex externally and internally, and presents a slight basal ridge antero-internally and postero-externally. The apex of the crown is worn off, leaving a subcircular dentinal surface, continuous with an exposed tract the whole length of the posterior side.

The true molars and the contiguous premolars are implanted by three fangs, two external and nearly vertical, and a third internal, broad, and apparently composed of two which are confluent.

The penultimate premolar is implanted by two fangs, also nearly vertical.

The face in the specimen containing the true molars is very much fractured, but in conjunction with the second fragment, a few characters may be obtained which are important.

The face is elongated, as in the Hog, but is not compressed laterally, as in Hyracotherium, but is demi-cylindroid, narrowing anteriorly.

The nasal bones extend as far back as to be on a line with the anterior margin of the orbit. They very gradually increase in breadth for two inches from behind, and then again gradually decrease. They form a continuous convexity with the maxillary bones. The frontal projects between the latter and the former, on a line with the posterior surface of the last premolar. The malar and lachrymal bones advance upon the face to about half an inch of the same line.

The hard palate is strongly arched from side to side.

ADMEASUREMENTS.

	Inches.
Estimated length of line of posterior five molars, ...	$4\frac{1}{3}$
Distance between the second true molars, ...	$1\frac{2}{3}$
Height of face on a line with the last premolar, ...	3
Height on a line with the second true molar, ...	4
Breadth of face above the second true molar, ...	$3\frac{3}{4}$

The species was dedicated to the late Dr. Samuel George Morton, formerly President of the Academy of Natural Sciences of Philadelphia, and author of Crania Americana, Crania Egyptiaca, etc.

Since writing the preceding description of the specimens upon which were established the Archæotherium Mortoni, I have had an opportunity of examining another and very important fragment of the same animal, which until now had not arrived from Dr. Owen's residence in Indiana. It belongs to the same collection of Nebraska fossils which form the basis of this part of Dr. Owen's Report. The specimen consists of the greater portion of the cranium proper, the right side of which is nearly entire, part of the forehead and face without the nasal bones and anterior extremity, and portions of both sides of the lower jaw (Tab. x., 1–3). It belonged to a young animal, as the sutures generally are separable, and the temporary teeth had not yet been shed.

In the upper jaw (Tab. x., fig. 1) of the specimen upon the right side are preserved in place the second and third temporary molars, and the three permanent true molars, the last of which still remained concealed within the jaw. On the other side the posterior permanent premolars have been exposed, and the anterior two permanent molars are in place. In the fragment of the right side of the lower jaw (Tab. x., fig. 2) a portion of the last temporary molar and the first permanent molar are preserved, and a part of the last permanent premolar is observed within the jaw at its anterior broken extremity. The other fragment (Tab. x., fig. 3) very much crushed, contains the three permanent true molars, the last of which had not yet protruded, a portion of the last temporary molar, and the last permanent premolar, which is partially exposed at the broken end of the specimen.

The skull (Tab. x., fig. 2) is quite peculiar in its form from that of any existing animal, and among known extinct species was probably most like that of Chœropotamus, to which Archæotherium is very closely allied. The cranium proper, in the great extent and general form of the temporal fossæ, separated by a high sagittal

suture, resembles the cat tribe, and more particularly the extinct genus Machairodus; while the vertical orbits are separated from the temporal fossæ by post-orbital arches, relatively as strong as in the Ruminants. The face posterior to the penultimate premolar is demi-cylindrical, and constructed very much like the corresponding portion of the head of Chœropsis. The specimen indicates an animal a little larger than the Chœropotamus parisiensis, *Cuv.*

Lateral view.—(Tab. x. 2.)—The temporal fossa has about the same length as the depth, and extends antero-posteriorly from the lateral margin of the inion to the posterior margin of the orbit, and in this direction measures in a straight line about the middle five inches. The breadth is relatively as great as in Felis or Machairodus, measuring from the upper edge of the zygomatic process two inches seven lines. The temporal surface from above downwards is convex, and about a third of its extent is contributed by the frontal bone. The squamous portion of the temporal bone is relatively small, appearing as if it was extended outwards to form the broad deep root of the zygomatic process, which, as in Sus and Dicotyles, originates on a line with the lateral border of the inion.

The squamous suture descends in an irregular convex line in an unusually abrupt manner, and the coronal suture after passing obliquely backwards and downwards upon the temporal surface for a little over an inch, then descends vertically an inch and a half posterior to the anterior margin of the temporal fossa.

The parietal bone has a remarkably broad descending process to join the sphenoid.

The outer margin of the zygoma posteriorly is broken in the specimen. The portion of the process which turns forward to join the malar bone, is about three-fourths of an inch deep, and curves upward.

The glenoid cavity appears to hold the same relative position as in the Peccary, but this, as well as the entire base of the cranium, is still enveloped in a hard matrix.

The meatus auditorius externus and its process, also obscured by matrix, appears to hold a position at the bottom of a deep fossa posterior to the glenoid articulation.

The orbital entrance is vertically oval, and is directed outwards and as much forwards as in the Cats, but not at all upwards. It is broader below than above, and its supra orbital margin is prominent outwards. Internally or anteriorly its margin presents a mammillary lachrymal process, above and below which it is notched.

The malar bone advances upon the face as far forward as the lower part of the anterior border of the lachrymal bone. Its inferior margin ascends anteriorly, and below the orbit its external face is bent upwards, and is remarkably shallow, being at the narrowest part just in advance of the middle of the orbit only half an inch, and behind the orbit it is as remarkably deep, measuring from the summit of the post-orbitar process vertically two and one-third inches.

The face is long, broad, and demicylindroid in form, though it appears comparatively narrow, with the great breadth of the cranium from zygoma to zygoma. The sides of the face are vertically convex, and the exit of the infra-orbitar canal is a large oval foramen, advancing upon a correspondingly large depressed portion of

the upper maxilla, situated three-quarters of an inch above the crown of the second temporary molar, and two and three-quarter inches in advance of the orbit.

The facial portion of the lachrymal bone is an oblong, quadrilateral plate, inclining forwards and upwards, and measures nearly two inches antero-posteriorly.

Upper view.—The cranium proper viewed from above has a very striking resemblance to that of the Cats. The brain-cavity is much shorter, and is relatively narrower, and more uniform in its breadth. The summit of the sagittal crest and of the protuberance of the apex of the inion are broken in the specimen, but sufficient remains to obtain a good idea of the form of both.

The apex of the occiput appears to have been quite as prominent as in the Tiger, though not so concave laterally, and posteriorly it appears to have been notched as in the Peccary. From it passes forward a high pyramidal sagittal crest, which has been about three inches in length to its bifurcation, which takes place just before reaching the coronal suture. The two branches proceeding from the crest are remarkably prominent and thick at their commencement, but gradually decrease in these respects, and diverge upon the frontal bone to the post-orbital arches.

The forehead in advance of the bifurcation of the sagittal crest, and along its middle line, is deeply depressed and uneven. From one orbit to the other exclusive of its middle depressed portion it is convex. Anteriorly, in the specimens, the connexions of the frontal bone are broken away, but the other specimens described indicate the existence of angular processes, proceeding forward between the broad lachrymal plate and the nasal bones to join the upper maxillary, as in Chœropsis.

Inferior maxilla.—Both fragments of the lower jaw are too much crushed to gain many characters of importance from them. That of the right side, which is best preserved, is not quite two inches in depth below the first permanent true molar. Below the position anteriorly of the unprotruded last permanent premolar, a process projects from the base outwards and downwards, like in Anthracotherium.

Dentition.—The superior anterior two permanent molars have been already described, and it is therefore unnecessary to say anything more about them in the specimen under examination, except that they are in a trifling degree longer, and the second is a little more convex at its sides; variations probably of a sexual character, but not improbably also only individual.

The last upper true molar is smaller than those in advance, and is more convex at its sides. The basal ridge anteriorly, and first row of mammillary eminences are as well developed as in the preceding molars, but the posterior row has dwindled down in connexion with the corresponding portion of basal ridge into about four low tubercles.

The superior two premolars described in one of the specimens, were so much worn that another description of the two preserved in the present one (Tab. x., fig. 1), which had not yet protruded, will be important.

The crown of the last premolar is constituted by two large conoidal lobes, of which the internal is about one-third smaller than that situated external. At the base of the lobes, anteriorly and posteriorly, there exists a basal ridge; better developed and tuberculate in the latter position.

The crown of the penultimate premolar is a transversely compressed cone, having developed at its base antero-internally, and in a less degree postero-internally, a basal ridge.

The upper temporary true molar is quadrilateral, with the inner three sides combined into one convexity, and is longer than it is broad. It is constructed after the type of the permanent true molars, but the anterior basal ridge and the inner mammillary eminences are relatively not so well developed.

The penultimate premolar presents the characteristic elongated form of the temporary tooth of the series in most Ungulata. It looks as if formed by a prolongation of the anterior lobes of a tooth like the last temporary molar, and the association of its anterior mammillary eminences into a single one. The inferior permanent true molars present a striking resemblance of form to those of the Peccary, with which Archæotherium is a near relative. They present in outline the figure-of-8 form, and all present two transverse pairs of mammillary eminences, with a feebly developed basal ridge anteriorly, and a thicker and tuberculated ridge posteriorly. The latter of the last molar is not better developed than in those in advance. A peculiarity of these teeth of Archæotherium is the division at summit of the antero-internal lobe into two. The fragment of the last inferior temporary molar preserved in the specimen, is constructed on the same pattern as those just described, and, as in most Ungulates, had six lobes to the crown arranged in three transverse rows.

The last permanent premolar, which had not yet protruded, and is partially exposed only in the specimen, appears to have the same form as the penultimate premolar above.

From none of the permanent molars being worn to any extent in the specimen, the enamel presents a remarkably wrinkled appearance, particularly upon the sides of the eminences of the true molars.

ADMEASUREMENTS.

	Inches.
Estimated length from the summit of the inion to the commencement of the nasal bones, ...	$7\frac{1}{4}$
Length from occipital condyle to the lachrymal process, ...	7
Breadth of skull at zygomæ, ...	8
" " cranium at middle of temporal surface, ...	$2\frac{1}{2}$
" at suture crossing the post-orbital arch, ...	$6\frac{1}{2}$
" of face at the anterior true molar alveoli, ...	$3\frac{1}{4}$

EUCROTAPHUS. *Leidy.*

EUCROTAPHUS AURITUS. *Leidy.*

(Tab. xv., figs. 1, 2.)

The genus Eucrotaphus was proposed in the Proceedings of the Academy, vol. v., page 92, upon a posterior portion of a cranium, remarkable for the large relative

size of the pars squamosa of its temporal bones. Since the description of the specimen the corresponding portion of the head of Oreodon has become known, between which there is a great degree of resemblance. In both genera the pars squamosa is very large, the temporal fossæ unite at the top of the cranium upon a sagittal crest, and the parietal bones, which are very narrow between the tops of the temporal bones, are also very much advanced in their position. In both, also, the glenoid articulation is nearly transverse, but in Eucrotaphus the post-glenoid tubercle is very much thicker. In this, also, the os tympanica forms a large auditory bulla, while it is reduced to little more than a prominent crest in Oreodon.

In Dr. Owen's collection is a corresponding portion of a cranium (Tab. xv., 1, 2) to that described of Eucrotaphus Jacksoni, but it is rather larger, and probably indicates a distinct species. In it the auditory bullæ are not simply mammillary, as in E. Jacksoni, but are laterally compressed ovoidal. For this second species the name Eucrotaphus auritus is proposed.

Nothing is certainly known of the dentition, or of the anatomical characters of the face of Eucrotaphus.

I suspect from the relation of size of the described fragments of the latter to the jaws of Agriochœrus,* and the general resemblance of the true molars of this to those of Oreodon, that the former two are really one and the same genus; but to determine this with certainty it must be left for further discovery.

MACHAIRODUS. *Kaup.*

MACHAIRODUS PRIMÆVUS. *Leidy* and *Owen.*†

(Tab. xii. A, fig. 5.)

Of this species Dr. Owen's collection contains a much fractured head, with the symphysis of the lower jaw, zygomata, and ends of the nasal bones broken away. Portions only of both superior canines, much fractured, remain in the specimen. The superior incisors were lost originally, and the alveoli are filled by matrix.

The cranium is one-fourth less in size than that of the Panther, Felis concolor, or about half that of Machairodus neogæus.

Lateral view.—(Tab. xii. A, fig. 5.) The temporal fossæ are relatively shorter and vertically deeper than in the Panther, and have a very much greater extent of surface anterior to a line drawn vertically from the glenoid cavity, and very much less posteriorly. A very large surface for attachment of the temporal muscle is also formed upon the post-orbital process, and the whole disposition of the temporal surface is to give a more vertical direction of the fibres of the temporal muscle in their course to the coronoid process than exists in the Panther and other species of Felis.

The para-mastoid and mastoid processes are combined into an oblique process an

* Proc. Acad. Nat. Sci., vol. v., 121.

† Ib. p. 329.

inch in its length and absolutely very much more robust and stronger than in species of Felis of larger size.

The passage to the meatus auditorius externus between the post-glenoid tubercle and the mastoid process is relatively very much narrower than in the Panther.

The face is more uniform in breadth along the course of the nose than in the Panther, and is convex and not depressed as in the latter, above the infra-orbitar foramina.

The forehead is elevated one inch above the extremity of the post-orbitar processes, is transversely very convex, depressed along the median line, and presents very obliquely forward.

The malar bones are relatively narrow; the face below their anterior extremity relatively broad.

The infra-orbitar foramina are twice the size of those of the Panther. The orbits present in about the same direction as in the latter. The squamous, coronal, interparietal, and interfrontal sutures are obliterated. The fronto-maxillary and naso-frontal sutures are strongly serrated.

The intermaxillary bone reaches to within a half inch of the frontal.

In the lower jaw a striking character is the relatively short coronoid process which is also vertical, or not at all curved backward. The post-coronoid process bends outward instead of inward, as in the species of Felis. About three inches from the condyle, near the base, and proceeding to it, is a ridge, apparently the commencement of the inferior margin of the remarkable alar process of the chin of Machairodus.

Dentition.—The superior canines, judging from their much mutilated stumps, have been very long, compressed in form, but relatively narrow antero-posteriorly to those of Machairodus neogæus. At their alveoli they measure seven lines antero-posteriorly, and four lines transversely. The concave border of one of the teeth in the fossil, nine lines below the base of the enamel, commences to be trenchant, and delicately serrulated. Also, antero-internally, the oblique serrulated ridge begins at the base of the crown, and is directed anteriorly.

The superior incisive alveoli remain in the specimen: they are of very large size, and increase from the first at the median line to the last, and leave no interval or hiatus between the latter and the superior canine for the reception of the lower canine.

The hiatus between the superior canine and the second molar, the first having been shed, as if depending upon the diminished breadth of the former, compared to its condition in Machairodus neogæus, is unusually large, being seven lines.

The second molar relative to that of the Panther, is small; it is also short in relation to its breadth. It has three distinct lobes: an anterior, oblong talon, a posterior, simple, compressed, trenchant lobe, separated by a notch from a middle, compressed, conoidal cusp.

The superior carnassial tooth presents the same form as in Machairodus neogæus, and is particularly distinguishable from that of the true Cats by its middle lobe being broad and trenchant instead of pointed.

In the lower jaw, as before mentioned, the chin is broken away, but upon one

side, nine lines of hiatus remains anterior to the first molar, below which the surface is depressed for the better accommodation of the superior canine.

The first molar has three lobes: an anterior and a posterior rounded talon, and a middle, compressed conoidal cusp. The former are nearly equal in size and the latter is a little larger.

The second molar is relatively longer than that of Felis. It also has three lobes, the anterior of which is relatively broader than that of M. neogæus, and is nearly equal to the posterior, which is notched at summit. The middle lobe is long conoidal compressed.

The inferior carnassial tooth is relatively broader than that of M. neogæus, and is more complex in its form from the presence of an additional lobe to that already existing in excess in this species, beyond what it is in Felis.

ADMEASUREMENTS.

	Inches.	Lines.
Length from occipital condyle to superior incisive alveoli,	6¼	
Breadth above the superior carnassial tooth,	3	
" at canine alveoli,	2	
Antero-posterior diameter of superior carnassial tooth,		10

DESCRIPTIONS OF CHELONIA.

TESTUDO. *Linnæus.*

In Dr. Owen's collection of fossil remains from Nebraska, there are four species of Turtles, belonging to the genus Testudo.

The carapace of the latter is composed ordinarily of ten vertebral plates, eight pairs of costal plates, and eleven marginal plates each side of the nuchal and pygal plate.

The first vertebral plate is quadrilateral, with convex sides, and long and narrow.

The succeeding plates to the penultimate are most frequently hexahedral.

The penultimate plate is inverted V-shaped, and the last is rhomboidal, and received between the preceding and the pygal plate. The costal plates are alternately broad and narrow.

The carapace is also invested by five vertebral scutes, four pairs of costal scutes, and eleven marginal scutes, each side of a narrow nuchal, and a broad undivided pygal scute.

The sternum is composed of an entosternal plate, and four pairs of lateral plates, invested by eight pairs of lateral scutes, including those supplementary to the axillary and inguinal notches.

All the specimens of fossil Turtles above referred to, belonged to immature individuals, as the costal plates were still united by cartilage to the marginal plates when the animal died.

TESTUDO NEBRASCENSIS. *Leidy.*

(Tab. xii. A, figs. 1, 2.)

Stylemys Nebrascensis: Pr. Ac. Nat. Sci., vol. v. 172.
Testudo Nebrascensis: ib., vol. vi., 59.

This species was first characterized as belonging to a new genus, under the supposition that the processes which rise upwards from the sternum to aid in the support of the carapace were distinct bones, a mistake which arose from their unusual size and prominence, and their being detached by fracture from the sternum.

In Dr. Owen's collection, there are two specimens of this species, varying in size, and in some degree in minute anatomical detail. Both have the marginal plates broken away in front and behind, and the larger has lost nearly all its carapace, and the smaller the anterior portion of the sternum. The carapace of the smaller specimen has a vertebral plate in excess introduced between the eighth and the V-shaped plate.

The species is more depressed than the Gophir, and has more the form of the Emydes than the Testudines. The sternum is flat, and the axillary and inguinal notches are directed downwards.

The marginal plates are quite oblique above, and turn abruptly under at their lower third. The bones are relatively thick and strong.

In the smaller specimen the first vertebral plate is ten lines long and six broad. Those from the second to the eighth inclusive are hexahedral; the anterior four being the larger and nearly equal in size. The ninth or accessory plate is transversely oblong, quadrilateral.

Each vertebral plate after the first to the eighth inclusive, articulates with two pairs of costal plates.

The first costal plate externally articulates with the first to the third marginal plates, but does not quite reach the fourth. The vertebral scutes from the second to the fourth inclusive, are hexahedral, and broader than long.

The sternum agrees in its characters in both specimens, except in the smaller, the anterior border of the humeral scute courses along the posterior edge of the axilla, whereas, in the larger, at its external part, it turns forwards and outwards to the axilla.

The entosternal plate is pyriform, and is longer than it is broad, and encroaches upon the position of the gular scutes.

In the larger specimen the episternals are one and a half inches long. The hyosternals are two and a quarter inches long, and articulate with the third to the fifth marginal plate inclusive.

The hyposternals articulate with the fifth to the seventh marginal plates.

The gular scutes are angular posteriorly. The humeral scutes internally are six lines long, and externally expand before and behind, and join the axillary and the fourth and fifth marginal scutes.

The abdominal scute, in the smaller specimen, joins the sixth and seventh marginal and the inguinal scutes, and in the larger specimen, the latter and the sixth and fifth marginal scutes.

ADMEASUREMENTS.—TWO SPECIMENS.

	SMALLER.		LARGER.	
	Inches.	Lines.	Inches.	Lines.
Estimated length of sternum, . . .			7	
Breadth, ...	4	9	5	6
Height, ...	2	11		

TESTUDO OWENI. *Leidy.*

(Tab. xii. A, figs. 3, 4.)

Emys Oweni: Pr. Ac. Nat. Sci., vol. v., 327.
Testudo Oweni: ib., vol. vi., p. 59.

This species is established upon a nearly entire carapace and plastron. The former is more convex than in the Gophir, and posterior to the fifth vertebral plate is more retuse.

The costal plates in the individual were yet united by cartilage to the marginal plates. The latter at the sides are vertically convex; anteriorly and posteriorly less shelving than the dorsum generally; and above the axillary and inguinal notches slightly reflected.

The sternum is flat except at the union with the carapace, where it is convex, and anteriorly is turned upwards.

In the specimen there are ten vertebral plates. The first is one and a half inches long and ten lines broad. Those succeeding to the eighth inclusive are hexahedral and articulate each with two pairs of costal plates.

The tenth vertebral plate is fourteen lines long and seventeen broad.

The nuchal plate comes in contact only at the anterior angle of the first costal scute, and measures three and three-quarter inches in breadth, equal to the first vertebral scute.

The second and third vertebral scutes are nearly equal in size, each being about two inches seven lines broad, and the former two inches long, and the latter one line greater. The lateral margins are parallel and bow-shaped. The fourth vertebral scute is slightly broader than long, and the lateral margins are bow-shaped and convergent posteriorly from their middle.

The entosternal plate is pyriform with the anterior extremity bordering the margin of the gular scutes, and the base extending to the humeral scutes. It is twenty-eight lines in length and breadth.

The hyosternals are three and a half inches long, and articulate with the third to the angle inclusive of the sixth marginal plates.

The hyposternals are two and a half inches long at their middle, and articulate with the sixth and seventh marginal plates.

The gular scutes are convex posteriorly, and do not encroach upon the position of the entosternal plate.

The humeral scutes internally average seven and a half lines long, but externally expand before and behind, and join the axillary scutes and the fourth, fifth, and sixth marginal scutes. The abdominal scutes are three inches long, and join the sixth and seventh marginal and the inguinal scutes.

ADMEASUREMENTS.

	Inches.	Lines.
Length of sternum at middle line,	10	
Breadth " at posterior margin of hyosternals,	7	
Estimated length of antero-posterior curve of the carapace,	13	6
Height,	5	6

TESTUDO CULBERTSONII. *Leidy.*

(Tab. xii.)

Emys Culbertsonii: Pr. Acad. Nat. Sci., vol. vi., p. 34.
Testudo Culbertsonii: ib. p. 59.

This species is established upon a nearly entire carapace and plastron, a little crushed out of its original form upon one side. It is much larger than Testudo Oweni, and is relatively less convex and high in comparison to its length and breadth.

The marginal plates laterally are vertically convex.

The sternum is concave, indicating a female individual, and the axillary and inguinal notches are directed downwards.

The carapace in the specimen has eleven vertebral plates.

The first vertebral plate is two and a quarter inches long and one and a half inches broad.

The second vertebral plate is octohedral, with alternately long concave and short straight sides, and articulates laterally with the first, second, and third pairs of costal plates.

The third vertebral plate is quadrilateral, and articulates laterally with only the third pair of costal plates. The arrangement of the two last described vertebral plates is very similar in the recent Gophir.

The other vertebral plates to the eighth inclusive are hexahedral. The ninth vertebral plate is quadrate, and is an accessory to the usual number introduced between the eighth and the penultimate, or inverted V-shaped plate.

The second and third vertebral scutes are broader than long, quadrilateral, with the lateral margins bow-shaped. The fourth vertebral scute is considerably longer than broad, and the fifth is prolonged at its anterior part to join the former.

The entosternal plate is pyriform, and is a little broader than long.

The hyosternal plates are over five inches long, and articulate with the third to the angle inclusive of the sixth marginal plates.

The hyposternals are four inches long, and articulate with the sixth and seventh marginal plates.

The gular scutes are acute behind, and encroach for three-fourths of an inch upon the position of the entosternal plate.

Internally the humeral scutes average eleven and a half lines long, and externally join the axillary and the fourth and fifth marginal scutes.

The abdominal scutes are four and a half inches long, and join the sixth and seventh marginal and the inguinal scutes.

ADMEASUREMENTS.

	Inches.
Estimated length of sternum,	15
Breadth,	11
Height,	$6\frac{1}{2}$
Length of antero-posterior curve of the carapace (estimated),	22

TESTUDO HEMISPHERICA. *Leidy.*

(Tab. xii. B, figs. 1, 2.)

Emys hemispherica: Proc. Acad. Nat. Sci., vol. v., 173.
Testudo hemispherica: ib.

This species was first established upon a specimen of a sternum with a small portion of the carapace from the collection of Mr. Culbertson.

In Dr. Owen's collection is a specimen consisting of almost the whole of a carapace and sternum, but much fractured and otherwise mutilated. It is relatively higher or more convex than any of the preceding, and is rather hemioval than hemispherical as the name indicates.

The costal plates were still connected by cartilage to the marginal plates at the time the animal died.

There are ten vertebral plates. The first is quadrilateral and twice as long as broad. Those succeeding to the eighth inclusive are hexahedral. The second to the fifth are nearly equal in size, and the others gradually decrease. The tenth plate is a regular trapezium, enclosed by the ninth or inverted V-shaped plate and the pygal plate, and is divided at its middle by the last vertebral scute.

The first costal plate is thirty-three lines long by eighteen broad, and articulates with the first, second, and three-fourths of the third marginal plates.

The lateral marginal plates are nearly vertical, being bent under only in a relatively slightly convex manner at their lower fourth.

The first vertebral scute comes in contact with the first marginal plate at its postero-internal angle, where it measures two and a half inches broad. The second and third vertebral scutes are of nearly equal size, being two and a half inches wide and twenty-two lines long.

The axillary notches present outwards and downwards; the inguinal notches downwards.

The sternum anteriorly shelves upward, and its margin the breadth of the gular scutes, though not truncated, is very obtuse, and posteriorly it is notched.

The entosternal plate is as broad as it is long, being about two inches, is short pyriform, reaches the border of the humeral scute behind, and encroaches a half inch upon the position of the gular scutes.

The hyosternal plates articulate with the third to the anterior angle inclusive of the sixth marginal plates.

The hyposternals articulate with the sixth and seventh marginal plates.

The humeral scutes internally are half an inch long, and their anterior border externally curves forwards and outwards to the axillæ. They join the axillary and the fourth and fifth marginal scutes.

The abdominal scutes are two and three-quarter inches long, and join the sixth and three-fourths of the seventh marginal and the inguinal scutes.

ADMEASUREMENTS.

	Inches.	Lines.
Length of the sternum at the middle,	8	6
Breadth to articulation with the marginal plates,	6	3
Length of antero-posterior curve of the carapace (estimated),	13	
" transverse curve from a level of the sternum,	14	
Height of carapace from level of the sternum,	5	

CONCLUSION.

Besides the various remains of Mammalia and Chelonia described or mentioned in the preceding chapters, a number of others have been obtained from the same locality, of which the following list is a synopsis.

PŒBROTHERIUM WILSONI. *Leidy.*

An extinct species and genus of Ruminants most closely allied to the existing Musks or the extinct Dorcatherium, *Kaup*, of Europe. It was established in the Proceedings of the Academy of Natural Sciences of Philadelphia, vol. iii. p. 322, for 1847, upon the greater portion of a skull containing nearly all the molar teeth, of which those temporary had not yet been shed. The specimen was presented to the Academy by Mr. Joseph Culbertson.

The head is most remarkable, so far as can be ascertained, for the possession of the full or normal number of molars, the great narrowness of the face, the large size of the auditory bullæ, and the prolongation of the technical angle of the lower jaw into a hook, an approach in resemblance to which among existing Ruminants we find in the Camel.

AGRIOCHŒRUS ANTIQUUS. *Leidy.*

An extinct species and genus of Ruminants, which is one of the lost links of the wide interval between existing members of the family and the very aberrant form, the extinct Amplotherium, *Cuvier*, of the tertiary formations of Europe and Asia.

It was established in the Proceedings of the Academy of Natural Sciences, vol. v., p. 121, for 1850, upon the anterior portion of a skull, containing in both jaws nearly all the molars received for examination from the Smithsonian Institution.

The molar teeth are decidedly constructed upon the same pattern as those of modern Ruminants, and the true molars are most like those of the extinct Merycopotamus, *Falconer* and *Cautley*, of the Sivalik Hills of India. The orbits, however, are not closed behind, as in the latter and existing Ruminants, but are open, as in Anoplotherium.

ARCHÆOTHERIUM ROBUSTUM. *Leidy.*

Arctodon: Proc. Acad. Nat. Sci., vol. v., p. 278.

This second species of Archæotherium is founded upon several fragments of molar teeth, and the crown of a canine which belonged to a larger animal than the Archæotherium Mortoni. The portions of teeth resemble so much those corresponding to them in the Bear, that I thought they certainly belonged to a closely allied genus, but was undeceived by an examination of the very beautiful specimen of a head containing nearly all the molars of Archæotherium Mortoni, in the collection of Dr. Owen.

ANCHITHERIUM BAIRDII. *Leidy.*

Palæotherium Bairdii: Proc. Acad. Nat. Sci., vol. v., p. 122.

Cuvier described the remains of a pachydermal quadruped, which he named Palæotherium aurelianense. This has since been certainly determined by the researches of Lartet, De Christol, and Pomel, to be a solipedal animal, for which the generic name of Anchitherium had been proposed by Von Meyer, and the species should therefore be named Anchitherium aurelianense. Among the remains of Mammalia from Nebraska, loaned to me for examination by the Smithsonian Institution, is the greater portion of a cranium, and fragments of jaws, containing full series of both upper and lower molar teeth, and a first phalanx.

The latter undoubtedly indicates a solipedal animal, and the molar teeth have the exact construction of those of Anchitherium aurelianense, to which, in comparison, the Anchitherium Bairdii was about three-fifths the size.

TESTUDO LATA. *Leidy.*

Proc. Acad. Nat. Sci., vol. v., p. 173.

This, the largest of the fossil Turtles from Nebraska, was established upon a specimen consisting of the greater portion of a carapace and sternum, in the collection of the Smithsonian Institution. It has been about two feet in length, twenty inches in breadth, and about nine inches in height.

APPENDIX.

ARTICLE I.

DESCRIPTION OF NEW AND IMPERFECTLY KNOWN GENERA AND SPECIES OF ORGANIC REMAINS, COLLECTED DURING THE GEOLOGICAL SURVEYS OF WISCONSIN, IOWA, AND MINNESOTA, BY D. D. OWEN.

CRUSTACEA (TRILOBITES).

DIKELOCEPHALUS. (N. G.)

Generic character.—Cephalic shield semicircular, and rather flat, glabella moderately convex, equally wide throughout, rounded in front, divided by *two* furrows into three *distinct* lobes; these well-marked furrows extend quite across the glabella, and form a curve or slightly obtuse angle in the median line directed backwards; the anterior lobe is partially divided by a third *obscure* furrow, which becomes obsolete in the median line.

Facial sutures distinct, originating at the anterior border of the cephalic shield; they run at first parallel with the same, then converging in a sigmoid flexure around the eye-plate, diverge again in curved lines, until reaching the anterior border, they circumscribe an area of greater or less extent in front of the glabella.

The cheek-plates produced at their anterior corners into spines of moderate length, as indicated by various detached cheek-plates, one of which, found in the buff-bed near the base of La Grange Mountain, is shown by Fig. 3, Tab. I., A.

Pygidium rather deeper and about the same width as the cephalic shield; axal lobe smaller than the lateral, with from four to six segments; the last and largest segment sometimes obscurely subdivided by a faint furrow. Lateral and interlateral segments blended into a marginal flap or border of greater or less extent; usually, if not always, provided with caudal spines.

Relations and differences.—The genus *Dikelocephalus* approaches on the whole nearest to *Ogygia*, but the middle lobe of the pygidium has fewer segments, and is much shorter and blunter; the glabella is not contracted posteriorly, and two transverse furrows extend quite across the glabella, in this respect having a greater similarity to *Trilobites Sternbergii*,* but from which it also differs in the anterior furrow, and in the basal lobe not assuming a tuberculated character.

* See Table III., figs. 7 and 8, organization der Trilobiten, von Hermann Burmeister, for which Dr. Beyrich proposed the generic name of *Chirurus*. This genus, as given by Hawle and Corda, differs, however, in the form and lobes of the glabella from Burmeister's figure of this Trilobite, and in the caudal shield there is a wide difference. See Tab. VI., fig. 70, of their work.

The form of the eye has not been satisfactorily ascertained, but it is probably similar to that of *Ogygia*.

Number of thoracic segments only indistinctly indicated by detached fragments, which, together with analogy of form, render it *probable* that they were eight in number. With the exception of one or two specimens, occurring in the Lower Magnesian Limestone, F. 2, all the individuals and species of this genus have been found in the Lowest Sandstones of Wisconsin, Iowa, and Minnesota, F. 1.

DIKELOCEPHALUS MINNESOTENSIS. (N. S.)

(Tab. I., figs. 1, 2, 10; Tab. I. A, figs. 3, 6.)

Specific character.—The principal distinctions between this and the other species of the genus are its larger size, less convexity of the glabella, the greater extent and slightly concave, shovel-shaped area expanded in front of the glabella; with the greater size of the caudal flap and the shortness of the caudal spines, set wide apart, and projecting vertically backwards;* five or sometimes six segments in the axal lobe of the pygidium, since the terminal and largest lobe is usually, though obscurely, divided by a faint furrow.

Dimensions.—Cephalic shield $1\frac{7}{10}$ long; caudal shield $2\frac{3}{10}$ long, 4 inches wide.

This species was first found, and is most common, in a dark gray, argillo-calcareous bed intercalated in member *d* of F. 1, ninety or one hundred feet below the base of the Lower Magnesian Limestone, near the margin of Lake St. Croix, above Stillwater; towards the base of La Grange Mountain, and at the Great Slide, below Lake Pepin, on the Mississippi, which is the fifth Trilobite-bed of the series in F. 1. See table on page 52.

DIKELOCEPHALUS PEPINENSIS. (N. S.)

(Tab. I., fig. 9, *a* and *b*, fig. 13 (?), and Tab. I. A, fig. 17 (?).)

Specific character.—The glabella of this species is divided into three segments, without any partial furrow on the anterior lobe, which is relatively larger than in the preceding species; the other two are contracted into two narrow, basal segments. The facial sutures run almost parallel to the glabella, making a slight, sigmoid flexure, and leave but a very scant area between them and the glabella, which, in front, is almost in contact with the anterior, thickened border.

The caudal shield found associated (fig. 9, *b*), and which appears to belong to the same species, is small, highly arched; axal lobe wider in proportion than in the preceding species, with five articulations; border narrow.

Dimensions.—Cephalic shield $\frac{6}{10}$ inches deep; caudal shield about the same depth, and $\frac{9}{10}$ wide.

This species is found on the banks of the Mississippi River, in the buff, dolomitic layers near the top of member *d* of F. 1, near the base of La Grange Mountain, at the head of Lake Pepin.

Fig. 7, Tab. I. A, found associated in the same bed, is, most probably, the cheek- or wing-plate of the cephalic shield of this species, which is provided with lateral spines of great length. Part of the cephalic shield of another Trilobite has been found very analogous to this, and perhaps a variety of the same species, as it appears to differ only in having a narrow area in front of the glabella, between it and the thickened anterior border of about $\frac{2}{10}$ths of an inch wide.

DIKELOCEPHALUS MINISCAENSIS. (N. S.)

(Tab. I., figs. 3 and 12, and Tab. I. A, figs. 4 and 5.)

This species is, at present, only known by its pygidium, and a portion of the cephalic shield represented by fig. 3, *a*, *b*, Tab. I., and fig. 5, Tab. I. A. It differs from the *D. Minnesotensis* in being of smaller dimensions; in the glabella being more highly arched and elongated; in the cephalic shield being more rounded

* See fig. 2, Tab. I., where they are entire; in fig. 1, they are broken off.

and protuberant; in the area, in front of the glabella, being much narrower and convex rather than concave; in the pygidium being only provided with a simple border, and in its axal lobe having but four segments.

Number of thoracic segments not known. Fig. 4, Tab. I. A, is in all probability, the wing-piece and lateral spine of the cephalic shield of this species, as it is found at the same locality, associated in the same layers with fig. 3, *a* and *b*, Tab. I. No caudal spines have been found attached to the pygidium of this species, but it is not improbable that they existed.

Dimensions.—Cephalic shield 1 inch long, $1\frac{4}{10}$ wide from eye to eye; caudal shield $\frac{8}{10}$ inches long, $1\frac{4}{10}$ wide.

This species is found in greatest abundance in soft gritstones of a light greenish-gray colour; the third Trilobite-bed of F. 1, two hundred to two hundred and twenty feet below the top of that formation, near the mouth of the Miniskah River, at Mountain Island and elsewhere, associated with *Orthis* and *Lingula*.

DIKELOCEPHALUS IOWENSIS. (N. S.)

(Tab. I., fig. 4, and Tab. I. A, fig. 13.)

Specific character.—This species is merely known by its pygidium; it is supposed to belong to the genus *Dikelocephalus*, from the number of segments (4) of its axal lobe being the same as in the last (fig. 3), but it differs from it in being of smaller size, and in being provided with flattened caudal spines, set wide apart, larger in proportion than those of *D. Minnesotensis*, and, unlike them, they extend in curves obliquely outwards; border bounding the pygidium, simple and narrow. On the same slab with the Trilobite, and beneath it on fig. 4, are the compressed subconical bodies, which, very probably, are the detached caudal spines of larger individuals of the species. The individuals at present brought to light are much smaller than either of the preceding. Number of thoracic segments not known.

Dimensions.—Caudal shield $\frac{4}{10}$ inches long, $\frac{6}{10}$ wide.

It occurs near the palæozoic base of the lowest sandstone of the Upper Mississippi, below Mountain Island, and near the mouth of Black River, associated with Lingula and Obolus; more than five hundred feet below the base of the Lower Magnesian Limestone, F. 2.

DIKELOCEPHALUS GRANULOSUS. (N. S.)

(Tab. I., fig. 7 (and 5?).)

Specific character.—This species is distinguished particularly by the glabella and cheek-plates, as far as they are preserved, being studded with minute granules. The glabella is divided by three furrows into four segments: the posterior segment terminates on either side in two obscure basal tubercles.

Fig. 5 of Table I. is supposed to be the caudal shield of this species; it is wider in proportion to its length than any of the preceding species, and parabolic in form. Its axal lobe has three to four segments; a narrow and thickened border.

Dimensions.—Caudal shield, $\frac{4}{10}$ inches long, one inch wide; cephalic shield, $\frac{4}{10}$ long, as far as preserved.

This species occurs in the third Trilobite-bed, at the mouth of Miniskah River, associated with a small Orthis, and another Trilobite, Tab. I., fig. 11, more than two hundred feet below the base of the Lower Magnesian Limestone, F. 2.

LONCHOCEPHALUS. (N. G).

Generic character.—In this small and singular genus the highly-arched glabella is either undivided, or has only two very obscure furrows. A spine of greater or less length projects backwards from the base of the glabella, in the median line of the body over the thoracic segments; fig. 12, Tab. I. A. The pygidium found associated in the same beds is semilunar, with little or no border, and has four segments of the axal lobe.

LONCHOCEPHALUS CHIPPEWAENSIS. (N. S.)

(Tab. I. figs. 6, 14; Tab. I., A, fig 9.)

Specific character.—This very minute species of *Lonchocephalus* rests chiefly on its small, semi-elliptical glabella, being little more than from one-tenth to three-tenths of an inch long; in the short spicula, a spine projecting backward in the median line from the base of the glabella; in the horseshoe-shaped area surrounding the glabella, and forming the cephalic shield; in the semilunar shape of the caudal shield (seen at the base of fig. 6, Tab. I.), with a very narrow border deflected downwards; the axal lobe with four segments.

This curious little Trilobite occurs by thousands in the soft gritstones of the Red Cedar or Menomonie branch of the Chippewa, occupying a position in F. 1 either of the third or fourth Trilobite-bed. In a slab measuring three inches square, more than one hundred individuals can be counted, but in no instance, as yet, have the thoracic segments been discovered.

LONCHOCEPHALUS HAMULUS. (N. S.)

(Tab. I., A, figs. 8 and 12.)

Specific character.—All that has yet been brought to light of this species is the glabella, with its remarkable appendage, and a portion of the cheek-plate.

The glabella is convex and undivided, quadrilateral in front, tapering behind, and provided with a long spine, attached to its base, and projecting, in the median line, in an arch backwards; this spine is much longer in proportion than that of the preceding species, and is formed in the shape of a fish-hook, as is well shown by a detached spine embedded in the medal-ruled slab, fig. 8; furrows of the glabella almost obsolete. The facial suture, as it proceeds with a slight sigmoid flexure around the ēye-plate, is in close proximity to the glabella; then slightly diverging, it circumscribes a circular area in front of the glabella, proportionally greater than that of *D. Minnesotensis.*

Caudal shield as yet unknown.

This Trilobite occurs in the same light greenish-gray gritstones of F. 1 as the *D. Miniscænsis*, upwards of two hundred feet beneath the base of the Lower Magnesian Limestone, F. 2.

CREPICEPHALUS. (N. G.)

Generic character.—Some rich Trilobite slabs, occupying the position of the third Trilobite-bed at the Mountain Island section, contain numerous fragments of a Trilobite, a portion of the cephalic shield of which is seen on the medal-ruled slab, fig. 16 of Tab. I. A, on the left corner, as well as by figs. 10 and 18 of the same plate. These, as far as preserved, approach somewhat in form to the genera *Solenosema*, *Micropyge*, and *Endogramma;* but if the caudal shields, fig. 8 of Tab. I., and fig. 16 of Tab. I. A, correspond, which seems improbable, as they are abundantly disseminated in the same bed, and are mineralized in the same manner into a brown, ferruginous crust, contrasting strongly against the gray gritstone, then this Trilobite of Mountain Island, must constitute a genus distinct from either of these, and for which the name *Crepicephalus* is proposed.

The rather flat, slipper-shaped glabella is tapering and slightly acuminated anteriorly, with a faint ridge in the median line; two small and very superficial depressions, and a posterior faint furrow, very partially divide the glabella. The facial sutures run nearly parallel to the margin of the glabella, and join a thickened, cord-like, anterior narrow border, enclosing a convex area, narrower in front than at the sides. Oblique plications can sometimes be traced on the cheek-plate, in advance of the eye, converging towards the apex of the glabella.

If the associated pygidiums, fig. 8 of Tab. I., and fig. 16 of Tab. I. A, belong to Trilobites of this species, they are relatively larger than those of any of the above genera. The axal lobe has four segments; side lobes bounded by a slightly concave border, which widens posteriorly, and of which the confines are almost rectangular, with rounded corners.

There are probably at least two species of this genus; one about a third larger than the other. The

larger of the two has the glabella less acuminated in front, and more rectangular, and the facial sutures more sinuous; but the distinctive specific characters of the two cannot be well established until more complete specimens are found.

MENOCEPHALUS. (N. G.)

Figure 11 of Tab. I. is the glabella and a small portion of the cheek-plate of a Trilobite, which will, no doubt, constitute a new genus, for which the name *Menocephalus* is proposed.

The glabella of this Trilobite differs from that of all the preceding in its circular, highly arched, and hemispherical form, and in being pustulated. Except this very characteristic form of the glabella, no other remains have yet been discovered that can be referred with any degree of probability to this genus, a further description of which must be deferred until the labours of the palæontologist can disclose more complete specimens of this highly interesting Crustacean.

ASAPHUS (ISOTELUS) IOWENSIS.

(Tab. II. A, figs. 1, 2, 3, 4, 5, 6, 7.)

According to Burmeister, Hawle, and Corda, this Trilobite would fall into the genus *Asaphus*, inasmuch as they consider that that genus has but *eight* thoracic segments; according to other authors, into the genus *Isotelus*, which, however, is not recognised as a distinct genus by the above writers on Trilobites.

The general form and contour of the cephalic shield closely resemble that of *Asaphus platycephalus* of Stokes (*Isotelus gigas* of Dekay); but the facial sutures do not converge in front to form a distinct angle, but describe three parts of an almost regular circle, as in *Asaphus expansus** (Hemicrypterus, according to Hawle and Corda), as shown by fig. 4, Tab. II., and fig. 5 of Tab. II. *a*, inadvertently inverted in position by the engraver.

Relations and differences.—This Trilobite stands as a connecting link between *Asaphus, Phacops, Hemicrypterus*, and *Isotelus*. Like many of the species of *Phacops*, it is provided with spines. The facial sutures do not form, as has been remarked, a *distinct* angle in front of the glabella, as in *Isotelus gigas*, but part of a nearly regular circle, as in *Hemicrypterus*. Like *Asaphus*, the eyes are reticulated, and the middle lobe of the caudal shield is defined (though *sometimes* somewhat indistinctly), but the segments are only obscurely pronounced. The axal lobe of the thorax is not as wide as in *Isotelus*, nor yet as narrow as in most species of *Asaphus*. Like *Isotelus*, the glabella is but obscurely defined.

From Dr. Locke's *megistos*, it differs in the eyes being set closer together; in the spines being longer—extending as low as the caudal shield; the pygidium more regularly elliptical; and its axal lobe more distinctly defined.

On Turkey River, in Iowa, where this species occurs, it seems never to have attained the great size which Dr. Locke's *megistos* did in Ohio; the largest specimens obtained at Turkey River are not quite four inches long. These differences we consider sufficient for the establishment of a new species. The uniform presence of spines at the angles of the wing in this Iowa fossil, as well as in the species found by Dr. Locke in the Blue Limestone of Ohio, and described by him under the specific name *megistos*, separates them from the *gigas* of Dekay, unless this can be shown to be a distinction of sex only.

CEPHALOPODA.

AMMONITES NEBRASCENSIS. (N. S.)

(Tab. VIII., fig. 3, and Tab. VIII. A, fig. 2.)

Specific character.—Discoidal, slightly convex, whorls one, and part of a second concealed in the terminal portion; flattened on the dorsum; surface ornamented with distinct, tuberculated ribs, every second or third of which is somewhat more prominent than the intermediate ones, which latter are thrown

* Some of the figures given by Hall of what he regards as *I. gigas* are but very slightly angled, and almost approach an arch. (See Palæontology of New York, Pl. 61, fig. 3 c, and *f*.) In all essential features, the *Isotelus* agrees with *Asaphus;* and if Burmeister is right in giving to this genus but *eight* segments, instead of *nine*, as previous authors have done, then the genus *Isotelus* must be abandoned.

off as bifurcations near the middle of the surface of the whorl, while the more prominent ribs originate at the umbilicus; all cross the dorsum in arches, the convexity of which is directed towards the mouth of the shell, fig. 3, *a*. The tubercles form four *distinct* concentric rows, and two *obscure* rows next the umbilicus; the two middle rows closest together; those near the umbilicus widest apart; row on the periphery most prominent. Diameter two inches. The original nacre of the shell is still preserved, with the lustre, appearance, and iridescent hues of mother-of-pearl.

Relations and differences.—This *Ammonite* is somewhat allied in its general aspect to *A. Conradi*, Pl. 16, fig. 1, described in Morton, "Synopsis of the Organic Remains of the Cretaceous Group;" but a comparison of authentic specimens in the collection of the Acad. Nat. Sci. of Philadelphia, shows that *A. Nebrascensis* is a third larger, the ribs more numerous and closer together, and has one more row of tubercles, the whole shell much flatter, and the ribs on the dorsum much more distinct. Dr. Morton considered figs. 2 and 3, on Pl. 16, of his Synopsis, as also fig. 4, Pl. 19, of the same work, as all varieties of the same species, *A. Conradi*, and remarks, page 39, "So variable, however, are its forms, that I was at first disposed to consider myself in possession of three species, which, however, upon a comparison of upwards of fifty individuals, appear to have their essential characters in common. The most remarkable of these varieties are Pl. 16, fig. 2, and Pl. 19, fig. 4."

After having carefully examined the specimen, in the collection of the Academy of Natural Sciences, from which the figures in the above work were drawn, I have no hesitation in saying that figs. 2 and 3, on Pl. 16, and fig. 4, on Pl. 19, are perfectly distinct specifically from fig. 1, Pl. 16; and, if *Scaphites** were a satisfactory genus, fig. 3, Pl. 16, and 4, Pl. 19, at all events, would certainly fall into that genus, since the last half whorl in these is destitute of sutured septæ, while in fig. 1, Pl. 16, they can be traced to the termination. D'Orbigny placed them all, in his "Prodrome," under the genus *Scaphites*, evidently from observing the recurvature of the last chamber in fig. 3, Pl. 16, of Morton's Synopsis, and hence that author referred all these figures to the same species (Conradi). Fig. 1, Pl. 16, is, however, in every respect a true *Ammonite*. The others will constitute two new species, for which we may select *gulosus* for fig. 2, Pl. 16, and *navicularis* for fig. 4, Pl. 19,—specific names which Dr. Morton himself provided, apparently in anticipation of future observations discovering characters and differences sufficient to establish them as distinct species.

A. Nebrascensis is one of the most common species of the cretaceous formation in the Fox Hills of Nebraska, which form the dividing ridge between the Cheyenne and Moreau Rivers, western confluents of the Missouri River, as indicated on the small map of that region.

AMMONITES (NEBRASCENSIS ?).

(Tab. VIII., fig. 2.)

Though this *Ammonite* bears considerable analogy to *A. Nebrascensis*, fig. 3 of the same plate, yet there are distinctions which may perhaps be sufficient to establish a new species. The shell has a greater diameter—two and one-quarter inches,—the ribs are fewer, wider apart, and bifurcate less frequently; the umbilicus is larger; rows of tubercles more obscure; outer chamber less expanded. Without having a greater number of individuals to compare, it would be unsafe to decide whether this *Ammonite* should be regarded as a distinct species. This *Ammonite* occurs with the preceding at the Fox Hills locality.

AMMONITES CHEYENNENSIS. (N. S.)

(Tab. VII., fig. 2.)

Specific character.—This species is not unlike a young *A. Nebrascensis*, but it is probably entitled to rank as a distinct species, on account of a peculiarity not observed in this or any other species hitherto described, i. e., the deflection outwards of the inner margin of the whorl that bounds the umbilicus, and in an additional row of tubercles.

Shell small (one to two-tenths of an inch in diameter), convex, enlarging rapidly; inner margin of whorl deflected outwards. Prominent tuberculated costæ, which bifurcate either near to the periphery, or two-thirds of the distance from it, passing over the dorsum of the shell in arches curved upwards. The

* For remarks on genus Scaphites, see under the head of *Scaphites* in this Appendix.

tubercles of the costæ form five concentric rows; the inner one obscure, and becoming obsolete one-third of the distance down the terminal volution. It is associated with the preceding.

AMMONITES OPALUS. (N. S.)

(Tab. VIII., fig. 6.)

Specific description.—Shell moderately convex, expanding, but gradually, towards the last chamber. Convolutions about two; last one embracing the preceding in a deep fossa. Surface destitute of tubercles, but ornamented with delicate, undulating ribs; every second, third, fourth, fifth, or sixth, more prominent than the intermediate ones, extends from the umbilicus to the periphery. Intermediate ribs formed by bifurcations, which take place about two-thirds and one-half of the distance towards the periphery, and, thus multiplied, cross the dorsum. Siphuncle visible where the shell is abraded on the dorsum (fig. 6, *a*). Umbilicus perforate? Serrations of the sutures represented by fig. 6, *a*.

Greatest diameter, two inches and a half; greatest thickness, one inch.

Remarks.—The specimens of this species from the Great Bend of the Missouri have often the nacre of the shell in the most exquisite state of preservation, and reflect light from their surface in the richest iridescent mother-of-pearl hues. They afford magnificent cabinet specimens. This species is associated, at the Great Bend of the Missouri, with *Inoceramus Cripsii*, in the cretaceous formation of Nebraska.

AMMONITES MOREAUENSIS. (N. S.)

(Tab. VIII. fig. 7.)

Specific character.—Shell small (one and a quarter inches in diameter); convolutions three and a half; about two-thirds of each whorl visible in the perforate umbilicus, the rest being concealed in a fossa of the terminal whorl; slightly convex; dorsum slightly flattened. Surface ornamented with undulating ribs; every second or third well defined. Intermediate ribs formed by bifurcations of the main ribs, which take place at different distances from the umbilicus. Four rows of *small* tubercles; the row on the periphery most prominent; the row next the umbilicus obscure.

Relations and differences.—This *Ammonite* has most analogy to *A. Abyssinus* of Morton; but it is larger; ribs more prominent; convolutions more numerous. Rows of tubercles on the *sides* of the volutions as well as on the periphery.

From the Fox Hills of Nebraska, associated with *Avicula*, fig. 10, Tab. VII., and some almost microscopic univalves.

AMMONITES LENTICULARIS.

(Tab. VIII., fig. 5.)

Specific character.—Shell small; remarkably thin, compressed dorsum a sharp edge; umbilicus very small; surface apparently smooth. Volutions, except the last, entirely concealed in the fossa of the ultimate whorl.

This specimen is not sufficiently well preserved to give a full description of it, but its lenticular form and remarkably sharp dorsal periphery serve to distinguish it.

Dimensions.—One and three-tenths inches.

From the Fox Hills, associated with the small *Avicula*, Tab. VII., fig. 10.

Relations and differences.—This species differs from *A. placenta* of Dekay, not only in size, but also in the serrations of the septæ, and in the umbilicus being much smaller and imperforate.

SCAPHITES OF PARKINSON.

Many of the convoluted and camerated shells of Nebraska are, I believe, destined to throw a new light on the forms hitherto referred to the genera *Scaphites* and *Ammonites.*

In 1811, Parkinson established the genus *Scaphites*, and gave the following generic description of it.

"A fossil concamerated shell, commencing with spiral turns; the last of which, after being elongated, is reflected towards the spiral part." He follows this description with these remarks: "The very wide

difference between the form of the *Scaphite* from that of the *Ammonite*, to which it approaches the nearest, is sufficient, I conceive, to show the propriety of a separation. I acknowledge that I was at first disposed to consider it as a monstrosity; supposing that the animal had by some accident been misdirected in its operations of forming its shell, and had thereby been led to the formation of it in this uncommon shape. A closer examination of the shell, however, set aside this opinion; for I then noticed the *tubercles on the sides of the straight part, which did not appear at all in the spiral, and but faintly in the recurved part.*"

Mantell, in his Medals of Creation, edition of 1844, gives the following definition of a *Scaphite.*

"Small chambered shells, of a *boat-like* form, with the inner whorls coiled up in a spire, and half hidden by the outer chamber, which becomes contracted and *recurved on itself, is destitute of septæ,* and terminates in an oval or transverse mouth. The syphon is dorsal."

D'Orbigny, in his Palæontologie Universelle, 1851, gives also a definition of this genus in the following words:

"Coquille formée d'une spirale regulière, enroulée sur la même plan, a tours contigus, crossant regulièrement jusqu'au dernier tour, qui se detache des autres et se projette en crosse plus ou moins allongée."

On applying these definitions and distinctions to the chambered convoluted shells of the cretaceous formation of Nebraska, they are found to be all at fault. Fig. 4, of Tab. VII., and fig. 4, Tab. VIII. of this Report, and figs. 2 and 3, Pl. 16, and fig. 4, Pl. 19, of Morton's Synopsis of Organic Remains of the Cretaceous Group, all go to prove that Parkinson's principal distinction, *by the tubercles,* is incorrect; the tubercles being equally distinct upon the spiral part and the deflected terminal portion, as on the straight part; indeed, in fig. 2, Pl. 16, of Morton, the tubercles are even more distinct on the deflected portion.

The *boat-shaped* form of the shell, caused by the deflection on itself of the last half whorl, is equally unsatisfactory, as Nebraska affords all possible gradations from the true boat-shaped form of fig. 4, Tab. VIII., to the regular Ammonite-whorl, figs. 1, 2, 3, 5, 6, and 7, of Tab. VIII. It was at first supposed that a satisfactory distinction could be found in the absence of *serrated* septæ in the last half or quarter whorl; but, on further examination, even this distinction was found to fail, since in two beautiful specimens of *A. Mantelli,* of Sowerby, in the collection of the Academy of Natural Sciences of Philadelphia, and in several of the chambered shells of Nebraska, the serrated sutures of the septæ were found to be entirely absent in the last half volution, though the shells have the normal Ammonite whorl. Now the syphon being dorsal both in the *Ammonite* and *Scaphite,* and the serrations of the sutured septæ perfectly analogous, I find myself completely at a loss to establish any generic distinction, that will enable me to decide whether certain fossils from Nebraska are *Ammonites* or *Scaphites;* and this is the very reason why we find D'Orbigny in his Prodrome referring *Ammonites Conradi* of Morton to the genus *Scaphites,* and why Morton was so puzzled in determining the species brought by Nicollet from the Upper Missouri. Unless some far more persistent character can be found on which to establish the genus *Scaphites,* than has yet been presented to us by palæontologists, the genus must be entirely abandoned and merged in the genus Ammonite, and the boat-shaped convolution and absence of septæ in the terminal part, must be regarded as *specific* and not *generic* distinctions.

SCAPHITES (AMMONITES?) COMPRIMUS. (N. S.)

(Tab. VII., fig. 4.)

Specific character.—Shell compressed and slightly boat-shaped. One volution visible, the rest concealed in the outer chamber. Surface ornamented with slightly curved costæ, which, on the chambered portion of the shell, are more than twice as far apart as on the terminal, deflected, non-camerated part. Every second or third rib runs to the inner margin; the intermediate ribs are formed by bifurcations, which commence one-fourth or one-half the distance towards the periphery. A row of small, pointed tubercles, on either margin of the flattened dorsum; a row of flatter and more obscure tubercles, one-fourth of the distance from the inner margin of the convolutions.

Dimensions.—Longest diameter, three inches; shortest, two and a half; greatest thickness, $\frac{7}{10}$ of an inch.

Locality.—Fox Hills, Nebraska.

SCAPHITES (AMMONITES ?) NODOSUS. (N. S.)

(Tab. VIII., fig. 4.)

Specific character.—Shell large* and ponderous. Volution subcylindrical, enlarging gradually towards the terminal chamber. Surface ornamented with sinuous costæ, most of which bifurcate at different distances from the umbilicus, and thus multiplied, proceed across the dorsum. Two rows of very prominent tubercles. The row near the periphery especially large and prominent, and from one-half to three-quarters of an inch apart. Aperture subovate. Serrations of sutures represented, fig. 4, *a*. Greatest diameter, four inches; greatest thickness, two and a half inches.

It is associated on Sage Creek, a southern tributary of the Cheyenne, with *Inocerami* of huge dimensions, one of which is represented by the medal-ruled plate, Tab. VIII. A.

GYROCERAS BURLINGTONENSIS. (N. S.)

(Tab. V., fig. 10.)

Specific character.—Scroll-shaped; volutions about two, rapidly enlarging; chambers forty-eight (?), indicated by undulating lines curving from the inner margin to the periphery.

This *Gyroceras* is of unusually large dimensions,—about fifteen inches in diameter, and nearly three feet along the dorsal circumference of a single coil. It occurs in the oolitic bed, at the top of member *a*, of the Lower Series of Carboniferous Limestones, under the encrinital beds of the quarries at Burlington, Iowa.

DISCITES TUBERCULATUS. (N. S.)

(Tab. V., fig. 14.)

Specific character.—In the character of the volutions, general form, and contour of the shell, this fossil resembles *Nautilus* (*Discites*) *subsulcatus* of Phillips, but differs in the back not being concave along the middle, but flat; also in the presence of a row of tubercles on either side of the flat dorsal surface; neither is there any concavity of the sides towards the outer edge.

Locality.—Iowa Point, Missouri River, in carboniferous limestone.

GASTEROPODA.

PLEUROTOMARIA MURALIS. (N. S.)

(Tab. II., fig. 6.)

Specific character.—Obtusely conical; convolutions five to six, with nearly vertical sides, like a spiral wall; upper surface of the whorls deeply channeled, and doubly carinated; undulating striæ, transverse to the convolutions. Height about two-thirds of the width.

From the Magnesian Limestones (F. 3) of Red River of the North.

STRAPAROLLUS (EUOMPHALUS) MINNESOTENSIS. (N. S.)

(Tab. II., figs. 12, 13.)

Specific character.—Flatly turreted above, deeply umbilicated beneath; convolutions about three, sharply angular, and carinated around the periphery, with a shallow canal on the upper surface; aperture small and subrhomboidal; $1\frac{3}{8}$ inches in diameter.

From the Lower Magnesian Limestone (F. 2), Traverse des Sioux, Minnesota.

* This is by far the largest boat-shaped concamerated shell that has ever come under my observation.

CONCHIFERA.

INOCERAMUS SAGENSIS. (N. S.)

(Tab. VII., fig. 3.)

Specific character.—Subovate or ovato-rhomboidal, convex, a wing-like extension of the anterior margin. Beaks blunt, slightly prominent. Angle formed by the hinge-line and axis a little less than a right angle. Broad, concentric, festoon-like, oval wrinkles of the surface. Length four inches; width three inches.

Relations and differences.—This fossil approaches in form to *I. myteloides* of *Goldf.*, but it is wider transversely, has no distinct concentric striæ between the broad wrinkles; beaks blunter; more elliptical in outline; hinge-line longer. From *I. Cripsii*, which it also somewhat resembles, it differs in being much more gibbous, and in the direction and dimensions of the hinge.

From the cretaceous formation on Sage Creek, southern tributary of the Cheyenne, associated with *I. Barabini* (?) and *I. Nebrascensis.*

INOCERAMUS NEBRACENSIS. (N. S.)

(Tab. VIII., fig. 1.)

Specific character.—Obliquely subovate or flatly rhomboidal egg-shaped; moderately convex. Umbos blunt and somewhat prominent. The hinge-line and axis form an acute angle of about 45°. Some twenty or twenty-one oblique, oval, concentric undulations of the surface, distinct but not prominent; broad, but faint rays, diverging from the umbo to the circumference.

Relations and differences.—This Inoceramus differs from *I. planus*, which it most nearly approaches, in being less circular, more convex, more inequilateral, umbos more prominent and gibbous, concentric undulations or folds more regular, angle formed by the hinge and axis more acute.

From the cretaceous formation on Sage Creek, Nebraska. The nacre of the shell, as well as most of those found associated with it on Sage Creek, is in as good a state of preservation as that of dead shells now on the sea-shore.

CUCULLÆA NEBRASCENSIS. (N. S.)

(Tab. VII., fig. 1, and 1, a.)

Specific character.—When both valves are united, this shell is heart-shaped or cardiform. The individual valves are subrhomboidal, oblique, inequilateral, equivalve; numerous minute, unequal, transverse, concentric striæ; hinge straight, and gently curved upward towards the beaks, which are slightly incurved, and not very distant; area with seven or eight rhombic furrows (formed by the margin of imbricated lamellæ). Transverse, lateral teeth three, both at anterior and posterior side, with three accessory lamellæ, the upper and under surface of which are roughened with fine transverse serrations. Central longitudinal teeth irregular. Anterior muscular impression long oval, and bounded beneath by a sharp, shelly projection, posterior rectangular; shell moderately thick. Length (with beak), two inches; breadth the same.

Relations and differences.—In its general shape this species is not unlike *C. transversa*, from the eocene tertiary, described and figured by William B. and H. D. Rogers, p. 373, Pl. XXIX., fig. 1, Contributions to the Geology of the Tertiary Formations of Virginia, Second Series; it differs, however, in several essential specific peculiarities; in the form of the lateral teeth, and their number on the posterior side; in having no longitudinal striæ, and the inner border not being crenulated; and in having three more furrows on the area of each valve.

From the cretaceous formation of the Fox Hills, between the Cheyenne and Moreau Rivers.

BRACHIOPODA.

LINGULA PINNAFORMIS. (N. S.)

(Tab. I. B, figs. 4, 6, 8.)

Specific character.—Shell shaped much like a *Pinna;* moderately convex; expanded, and running to a point at the beak, which in the dorsal valve is long, conical, and slender, curved towards the beak of the ventral valve, which it overhangs and embraces as with a deltidium. Surface marked with fine concentric striæ; when exfoliated, longitudinal striæ can also be detected towards the circumference of the shell. Length, $\frac{5}{8}$ of an inch; greatest width, $\frac{7}{16}$ of an inch.

This fossil is abundant in the siliceo-calcareous layers near the base of member *b* of F. 1, at the Falls of the St. Croix, Minnesota.

LINGULA AMPLA. (N. S.)

(Tab. I. B, fig. 5.)

Specific character.—This species has a greater circumference and superficial area than any of the others hitherto discovered in F. 1. Shell nearly oval, rather flat; beak blunt, and not projecting beyond the general contour of the shell, and formed more after the manner of the beaks of *Terebratulæ.* A few faint concentric striæ. Length, $\frac{11}{16}$ of an inch; width, $\frac{8}{16}$ of an inch.

This species occurs in the *Lingula* and *Obolus* grits, member *c*, near Mountain Island, at the Dalles of the St. Croix, and elsewhere in Wisconsin.

ORBICULA PRIMA. (N. S.)

(Tab. I. B, figs. 17 and 19, and top figures on Tab. 4.)

Specific character.—Shell obliquely depressed, conical; circumference nearly circular or slightly quadrangular; concentric and somewhat subquadrangular striæ. $\frac{4}{16}$ to $\frac{5}{16}$ of an inch in diameter.

Associated with the preceding species at the Falls of St. Croix, Minnesota.

ATRYPA COMIS. (N. S.)

(Tab. III. A, fig. 4.)

Specific character.—One of the valves of this *Atrypa* being broken and distorted, it only admits of a partial description. Shell subspheroidal; umbos but slightly prominent; surface smooth. Diameter about one inch. From the Davenport Limestone of the Upper Rapids of the Mississippi of Devonian date.

CHONETES GRANULIFERA. (N. S.)

(Tab. V., fig. 12.)

Specific character.—When first obtained, this *Chonetes* was referred to the species *C. variolata;* a closer inspection, however, induces the belief that it is a new species, since it differs from that species in the following characters:

The ribs, or rather striæ, are finer, and are not separated by other finer striæ, visible to a moderate magnifying power, nor are there any pits ("fossettes") to be observed on them. The surface of the concave, ventral valve is provided, like the *C. variolata*, with pustules, but they are fewer in number and less regularly disposed than shown on Pl. XX., fig. 2 *a*, of De Komich's work on "*Productus* and *Chonetes*."

The form of the medial tooth of the ventral valve, and the anatomy of its visceral portion, are different, as may be seen by reference to Tab. V., fig. 12 *b*.

From the carboniferous limestone, near the mouth of Keg Creek.

CHONETES (?) IOWENSIS (N. S.)

(Tab. III. A, fig. 7.)

Specific character.—Shell minute, about a quarter of an inch wide, and three-quarters of an inch deep; surface nearly smooth, with a few faint concentric lines of increase. It is possible that this fossil may be a minute species of *Strophodonta;* the spines of the hinge-line not being visible, and the shell being embedded so as to conceal the ventral valve, and prevent a view of the cardinal area, it is difficult to form a correct opinion in regard to it. Occurs on the Iowa River.

PRODUCTUS NEBRASCENSIS. (N. S.)

(Tab. V., fig. 3.)

Specific character.—In general shape, contour, and sinus, this *Productus* approaches *P. Humboldti;* but it is rather smaller, and differs in the structure of the surface, which, in the dorsal valve, is prominently and interruptedly ribbed, as if by the growth of spines directed downwards, and adhering for some distance to the surface, the intervals being the points where they were thrown off; these intervals are arranged in three or four concentric rows. Ventral valve pitted in numerous concentric rows, with intermediate concentric transverse lamellæ.

From the carboniferous limestone, Bellevue, Missouri River, Nebraska.

LEPTÆNA TRILOBATA. (N. S.)

(Tab. II., figs. 17, 18.)

Specific character.—This species was at first referred to the species *deltoidea,* but the form is so decidedly different in several respects, that it seems to constitute a distinct species. Dorsal valve broadly trilobate; very gibbous in front, and depressed towards the hinge-line; margin undulating, semi-oval; ventral valve concave; hinge-line extended; fine and equally radiating striæ, partaking of the curvature of the surface of the shell.

Relations and differences.—The outline of this shell is much more undulating, shell more gibbous and broader and more distinctly trilobate than the *deltoidea.*

It occurs in the shell-beds, F. 3 A, near the Agency, on Turkey River, Iowa.

STROPHODONTA OF HALL.

Generic character.—This genus, established by Hall, is intermediate between the *Leptœna* and *Productus.* In general appearance it resembles most the *Leptœna,* but has neither aperture nor deltidium; hinge-line is straight, as in *Leptæna,* but the area forms a trough, and has a toothed or crenulated structure; internal structure similar to that of the *Productus.*

It is probable that all, or almost all, the Leptæna-shaped fossil shells of the limestones of Iowa of Devonian date have the peculiar structure belonging to *Strophodonta.*

STROPHODONTA PARVA. (N. S.)

(Tab. III. A, fig. 9.)

Specific character.—Shell about half an inch wide; crescent-shaped; dorsal valve moderately convex; ventral, concave; surface of both valves finely ribbed, with twenty to twenty-three ribs.

From the shell-beds of New Buffalo, of the age of the Hamilton Group of New York.

STROPHODONTA (?) COSTATA. (N. S.)

(Tab. III. A, fig. 5.)

Specific character.—Shell minute, hardly three-eighths of an inch in diameter; regularly semicircular; eleven prominent ribs like those of a modern pecten; ventral valve nearly flat; dorsal slightly convex.

From the Davenport Limestone of Iowa, of Devonian date.

STROPHODONTA IOWENSIS. (N. S.)

Specific character.—The limestones of Pine Creek, Iowa, of Devonian date, furnish another species of *Strophodonta* of a lenticular form, not figured in this Report, smaller than fig. 14; convex valve only flatly arched; surface with delicate radiating striæ, with about four concentric lines of increase. Width, seven-eighths of an inch; depth, three-fourths of an inch.

ORTHIS CUNEATA. (N. S.)

(Tab. III. A, fig. 10.)

Specific character.—Shell wedge-shaped, circumference semicircular; both valves about equally convex; surface nearly smooth; with fine striæ only visible with a magnifier. Nearly half an inch wide, and four-tenths deep.

From limestones near New Buffalo, Iowa, of Devonian date.

SPIRIFER IOWENSIS. (N. S.)

(Tab. III., fig. 1.)

Specific character.—This species approaches in form to *D. mucronatus* of the New York Reports, but has fewer ribs; only ten or eleven on either side of the mesial fold; the sulcus is wider and not so deep; concentric lines of growth but little apparent; the decorticated portion of the shell shows a slightly undulating surface on the ribs. Length, one and a quarter inches; breadth, two and a quarter.

From the shell-beds of the Iowa River, of the age of the Hamilton Group of New York.

SPIRIFER PENNATUS. (N. S.)

(Tab. III., figs. 3 and 8 (?).)

Specific character.—This species is remarkable for the great extension of the cardinal area, terminating in produced angles or wing-like appendages, so that some specimens of this shell are nearly five inches from angle to angle. Cardinal area very wide, more than half an inch. On each side of the sulcus there are twelve distinct ribs, and five to six obscure ribs on the produced angles. Not imbricated by concentric lines of growth, as in the attenuated varieties of *D. mucronatus* (fig. 3, Nos. 4 and 5 Hall's New York Report).

From the shell-beds of the Iowa River.

SPIRIFER LIGUS (N. S.)

(Tab. III., fig. 4.)

Specific character.—This Spirifer is nearly as much produced at the angles as the last species, but the cardinal area is comparatively narrow, which character especially distinguishes it from the preceding species, as well as the greater number of ribs, which amount to twenty-six or twenty-seven, on either side of the bourrelet; the ribs are also more undulating, and have longitudinal striæ; this latter character, together with the more triangular form of the whole shell, and its greater convexity, separates it from the *D. medialis* of the New York Reports.

From New Buffalo, Iowa, in the shell-beds cotemporaneous with the Hamilton Group of New York.

SPIRIFER EURUTEINES.

(Tab. III., figs. 2, 2 *a*, 6, and 6 *a*.)

Specific character.—Shell nearly semi-elliptical; cardinal area very wide, slightly concave and finely striated; narrow perforation; beaks sometimes more than half an inch apart, smooth, with eighteen to twenty ribs on either side of the bourrelet, finely striated longitudinally, sometimes studded with small granulæ, bourrelet rather narrow, with a shallow sinus in the median line, finely striated, and crossed by fine concentric lines of growth, and sometimes by fine granulæ. Sinus of the dorsal valve, also sometimes finely granulated. Length, one inch, breadth one and a half inches.

This is one of the most common species of Spirifers in the limestones of the Red Cedar and Iowa Valleys, as well as the hydraulic limestone near the Falls of the Ohio. It was figured in the Report of 1839, but without any detailed description.

SPIRIFER CEDARENSIS. (N. S.)

(Tab. III., fig. 5.)

Specific character.—This Spirifer is much deeper from the beak to the circumference than either of the preceding, and, though very acute at the angles, it is much less produced along the hinge line. It differs, moreover, in the sulcus having small, longitudinal ribs. On either side of the mesial fold there are from twenty-three to twenty-five ribs; those on the angle are so fine that it is difficult to count them with precision. Shell considerably gibbous, especially towards the umbo. A few concentric wrinkles near the angles and border. From the limestones of Cedar Valley, two and a half miles below Rockingham, Iowa, of the age of the Hamilton Group of New York.

SPIRIFER INEQUICOSTATIS. (N. S.)

(Tab. V., fig. 6.)

In general shape this fossil resembles *S. semicircularis*, it differs, however, from that Spirifer, as well as from the *bisulcatus*, which De Koninck gives as a synonym, in several essentials, which appear to indicate a distinct species.

The ribs, though simple, are very unequal in size, some being exceedingly fine, others coarse; no distinct sulcus on the mesial fold other than the simple grooves between the ribs; the mesial fold or bourrelet is sharper and more divergent, by which it is much narrower near the beak.

Phillips does not give the number of ribs either on the mesial fold or general surface. This species has nine ribs on the mesial fold, and seventeen on either side of it, which is nearly the same as on the *bisulcatus*, according to De Koninck.

Dimensions.—$\frac{8}{10}$ long, $1\frac{3}{10}$ wide. Locality, carboniferous limestone of Iowa.

FORAMINIFERA.

SELENOIDES. (N. G.?)

Generic character.—It was supposed at first that this singular fossil from limestones of Lower Silurian date, F. 3, *a* (and *b*?), of Iowa, would fall into the genus *Orbitulina*. But as D'Orbigny regards this genus as unequal-sided *Orbitolites*, in which one side is convex, incrusted, and having concentric lines; the other concave, not incrusted, and showing numerous cells in oblique lines around the sides; it can hardly be grouped with it, as the Iowa fossil is umbilicated on one side, and the cellular, ring-shaped surface, instead of being concave, is so convex as to form nearly a coiled cylinder. The other side being partly defaced in splitting it out of the rock, it is difficult to say whether it had a cellular surface similar to that shown on fig. 13, Tab. II. B, or concentric lines; what portion of it is visible rather indicates that the fossil was unequal-sided, not being umbilicated on the other surface; probably cellular, and not with concentric lines. There are no cup-shaped cells opening round the periphery, as in *Orbitolites*, which are said to be *equal-sided Orbitulinas*.

For the above reasons, I think it will constitute a new genus, peculiar to the Lower Protozoic rocks. The horizontal section seems to present an internal arrangement of cells similar to those of *Orbitoides*.

SELENOIDES IOWENSIS. (N. S.)

(Tab. II. B, fig. 13.)

Specific character.—One side flatly dome-shaped, the other ring-shaped, enclosing an umbilicus or central depression. Small rhomboidal cells opening on the surface in curved rows, intersecting in arches; the cells gradually increasing in size from the inner margin to the periphery.

ARTICLE II.

DESCRIPTIONS OF ONE NEW GENUS AND TWENTY-TWO NEW SPECIES OF CRINOIDEA, FROM THE SUBCARBONIFEROUS LIMESTONE OF IOWA. BY D. D. OWEN, M.D., AND B. F. SHUMARD, M.D.*

PLATYCRINUS. *Miller.*

PLATYCRINUS PLANUS. (N. S.)

(Tab. V. A, fig. 4, *a*, *b*, *c*.)

Basal plate.—Somewhat cup-shaped, consisting of a single piece, pentagonal, smooth. The point for the attachment of the column is circular, slightly excavated, and has a minute central perforation, for communicating with the canal in the column. The surface of the plate is divided irregularly by three slightly raised lines, which commence at the central perforation, and extend to the superior margin, with a corresponding obscure canal in the interior. The upper edges between the angles of the pentagon are slightly concave, to accommodate the lower orbicular edges of the superior plates.

Superior plates.—Five, elongated, smooth, quadrilateral. Their length is about one-third greater than their breadth. The excavations for the insertion of the arms are rather deep, and occupy about one-half the breadth of the plates.

Column.—Round, moderately large, and striated in radii.

Abdominal plates and arms unknown.

In the appearance of its superior or arm-bearing plates, this species closely resembles *Platycrinus elongatus* of Gilbertson (Phillips's Geology of Yorkshire, Pl. III., figs. 24 and 26), but may readily be distinguished from the latter by the form of its pelvis, which is nearly cup-shaped, while that of *Platycrinus elongatus* is conical.

Formation and localities.—Occurs at Burlington, Iowa, in the subcarboniferous limestone immediately above the oolitic member of this formation, where it is associated with *Spirifer striatus*, *Productus punctatus*, *Orthis Michellini*, *Platycrinus granulatus*, and various crinoidal remains. Its geographical range is quite extended, since it is also found at Button-mould Knob, seven miles south of Louisville, Kentucky, in the blue shaly layers, interstratified with the fine-grained micaceous sandstone.

The *Platycrinus planus* sometimes attains a large size, indeed larger than any of the genus with which we are acquainted: a specimen from Burlington, though devoid of the abdominal plates, is nearly two inches in diameter.

PLATYCRINUS YANDELLII. (N. S.)

(Tab. V. A, fig. 6, *a*, *b*.)

Basal plate.—Somewhat massive, pentagonal, flattened, and rather deeply excavated at the point where the supra-columnar joint is attached; with a minute perforation in the centre corresponding to the canal

* Collected during the United States Geological Survey of Iowa, Wisconsin, and Minnesota, in the years 1848–49. Originally published in the Jour. Acad. Nat. Sci. Phila., New Series, Vol. II., Parts 1 and 2; now modified by additions and researches since that article appeared.

in the column. The surface is embellished with very prominent tubercles, usually arranged in a single series, just within and parallel to the outer borders of the plate.

The *superior plates* are five; broad, subhexagonal, and spreading towards the superior edges. The surface of each plate, like that of the basal plate, is studded with highly-raised tubercles; in some specimens these are disposed with great regularity in ranges parallel to the lateral and inferior edges; in others they are scattered irregularly over the plate. The excavations for the attachment of the arms are wide, shallow, and somewhat reniform. Each excavation is striated on the margin, and crossed near the middle by a transverse ridge, serving to prevent displacement of the arms.

The column and arms have not been discovered.

Dimensions.—Height of cup, four lines; breadth, seven and a half lines; height of superior plates, four lines; breadth of superior plates, five lines. This encrinite is nearly related to *Platycrinus rugosus* and *P. tuberculatus* of Miller, but is separated from those species by the more depressed form of the cup, the greater proportionate breadth of the superior plates, and the larger articulating surface for the arms.

Formation and locality.—It occurs with the preceding species in the subcarboniferous limestone at Burlington, Iowa. We have likewise discovered it near Salem, Indiana, holding a similar geological position. It affords us much pleasure, as a slight tribute of respect and esteem, to dedicate this beautiful species to our friend Professor L. P. Yandell, of Louisville, Kentucky.

PLATYCRINUS DISCOIDEUS. (N. S.)

(Tab. V. A, fig. 1, *a*, *b*.)

The general outline of the cup of this species is that of a decagon; and the visceral cavity is proportionally more shallow than in any of the hitherto described species of this genus, the diameter being about one inch, while the height is not quite three lines.

Basal plate pentagonal, massive, concave towards the centre, and bordered near the margin by an uneven ridge. The circle of attachment for the column is moderately large and finely striated. The margins of the plate are bevelled.

The *superior plates* are five; somewhat massive, subhexagonal, and increase in breadth towards the superior edges. The lateral and inferior margins of each plate are bevelled, so that when articulated to the basal plate and its fellows, a well-defined channel is formed at the sutures. A large portion of these plates goes to form the base of the cup, and occupies the same horizontal plane with the basal plate; being bent upwards only a short distance from the superior margin to form the sides of the visceral cavity. The articulating surface, for the attachment of the arms, is harp-shaped, slightly excavated, rather large, and finely striated on the margin. These surfaces are nearly perpendicular to the base, and their length is about equal to the entire height of the cup. A small groove, bounded by an uneven ridge, surrounds the inferior and lateral borders of each excavation. The surfaces of all the superior plates are ornamented with uneven ridges, two and sometimes three of which run parallel with the lateral and inferior margins; these are crossed, at their angles of junction, by two oblique diverging ridges, which commence at the lower border of the articulating surfaces for the arms; and proceed to the inferior angles of the plate. In some specimens the furrows between the parallel ridges are crossed by small connecting ridges.

The plates covering the abdominal cavity in their connexion are slightly arched, and nearly all of them have a mammillary projection rising from their centres. In the specimen which we have found with this portion of the animal preserved, the forms of only two of them can be made out; these are hexagonal, the others are so badly preserved that their shape cannot be satisfactorily ascertained.

The oral aperture, situated a short distance within the outer margin of this plated integument, is rather large, circular, and surrounded by a slightly elevated rim, composed of small plates.

Column and arms unknown.

Formation and localities.—A few specimens only of this elegant crinoid were obtained from the encrinital layers of the subcarboniferous limestone at Burlington. It was also found, holding a similar geological position, at Augusta, Iowa. At the latter locality we procured some detached superior plates, clearly appertaining to this species, measuring nearly an inch in the long diameter.

PLATYCRINUS CORRUGATUS. (N. S.)

(Tab. V. A, fig. 2, *a, b, c, d, e.*)

Body cup-shaped and somewhat pentagonal in its outline.

Basal plate pentagonal, flattened, concave in the centre and slightly convex towards the outer margin. The point for the articulation of the superior columnar joint is circular, moderately large, finely striated in radii, and exhibits a small round central perforation corresponding to the columnar canal; near the centre of the plate is the commencement of three furrows, which proceed to the edges of the plate, dividing it into three unequal parts. The surface is finely corrugated; in some specimens gathered into imbricating folds arranged in concentric lines, conformable to the shape of the plate.

The *superior plates* are five; broad, subhexagonal, and widen slightly from below upwards. The excavations for the attachment of the arms are harp-shaped, large, and striated around the margin, with a deep angular notch at the summit. The vertical diameter of the excavations is equal to about one-half of the length of the plate. The surfaces of the plate are finely corrugated, sometimes gathered in imbricating folds, finely striated, and disposed in lines parallel to the lateral and inferior margins. The articular edges are striated, as are those of the basal plate; and when connected together a deep angular gutter is formed at each of the sutures.

Arms.—We are only acquainted with the first joint of the arms of this species, which remains attached to a single specimen. It is cuneiform, the upper edges being bevelled so as to form two facets finely striated on the margin for the articulation of two series of arm-plates; the external surface is corrugated.

Column.—We have recognised merely a small fragment, consisting of the three superior plates of this portion of the animal, which is preserved in the beautiful specimen represented in fig. 2, *a.* They are circular at the basal plate, but become slightly elliptical as they recede from it; thin and of unequal diameter; each joint is sharply carinated on the side and presents a serrated appearance, from the elevated striæ on the articular surface of one plate fitting into the intervals between the striæ on the other.

Formation and localities.—This exceedingly neat and elegant species is rather rare, and occurs with the preceding in the subcarboniferous strata at Burlington, Iowa. We have not met with it at any other locality.

PLATYCRINUS BURLINGTONENSIS. (N. S.)

(Tab. V. A, fig. 5.)

Body cup-shaped, with a slightly pentagonal contour.

Basal plate pentagonal, flattened, smooth, moderately thick, convex towards the margins, and depressed in the centre, with a circular facet for the articulation of the supra-columnar joint.

Superior plates five; subhexagonal, smooth, slightly convex, and a little wider at their superior than at their inferior margins. The breadth of the plates is about one-fourth greater than the height. The articulating surface for the attachment of the arm is, in part, on the superior edge of the plate, and is somewhat reniform and shallow; in its longest diameter equal to about one-third the breadth of the plate.

Column, arms, and *abdominal plates* undiscovered. This species is easily distinguished from *P. lævis,* to which it is closely allied, by its more depressed form and flattened basal plate.

Formation and locality.—It is rare, a single specimen only having been obtained from the quarries in the subcarboniferous limestone at Burlington.

DICHOCHRINUS. *Münster.*

Basal plate hexagonal, composed of two pieces; superior plates six, five of which support the arms.

This genus was established by Count Münster to receive a crinoid possessing the above characters, viz., *Dichocrinus radiatus,* from the carboniferous limestone of Tournay, Belgium. Since then, other species have been discovered and published by authors. A species from the mountain limestone of Yorkshire is described by Messrs. Austen, under the name of *D. fusiformis* (Monog. Crinoid., p. 47, pl. 5, fig.6, *a–d*), and another figured in an early number of the same work as *Platycrinus elongatus* (Phillips), has in a

more recent number been removed to the genus under consideration, to which in the number of its superior plates, and the form of the basal plate, it more properly belongs.

In the United States, we are acquainted with five species appertaining to the genus *Dichocrinus*, all of which are from the carboniferous strata of the Mississippi Valley, and differ from any known European forms.

The opinion advanced by Messrs. Austen, that all the Crinoids occurring in the carboniferous limestone, with six superior plates, will be found to have a bi-partite basal plate, is fully borne out by our investigations. We have inspected a large number of specimens from the carboniferous rocks of various localities in Kentucky, Indiana, Illinois, and Iowa, and have invariably found this association to prevail where the superior plates rest immediately on the basal plate.

DICHOCRINUS OVATUS. (N. S.)

(Tab. V. A, fig. 9, *a*, *b*.)

The body of this beautiful species, when deprived of its arms, is of an ovoidal form.

Basal plate bi-partite, cup-shaped, hexagonal, thin, rounded; upper margin undulated to receive the orbicular edges of the superior plates; circle of attachment for the column slightly excavated, small, circular, and surrounded by a row of small and short spines. The surface of the plate is ornamented by depressed granulæ, arranged in rows, some of which commence at the margin of the excavation for the supra-columnar joint, and proceed to each angle of the plate; other lines run parallel with the undulating edges of the plate, forming a series of hexagons, one within the other, giving to the whole surface an exceedingly neat and elegant appearance.

Superior plates six, of which five are elongated, quadrilateral, rounded at the inferior edges, and support the arms; one is trapezoidal, wide, slightly angulated below and narrow above. The articular surfaces for the arms, situated on the superior edges of the five arm-bearing plates, are moderately large, very slightly excavated, striated on the margin, with a transverse ridge near the centre. All the superior plates are finely corrugated on the external surface.

Arms.—Several joints of the arms remain attached to one of the superior plates, in the only specimen we have been able to procure of this species. The first joint is of a rectangular form, and supports a cuneiform joint, on the bevelled edges of which is the commencement of two series of smaller plates. Each of these joints is distinctly corrugated on the dorsal surface.

Dimensions.—Height, nine lines; greatest width, 8 lines; diameter at summit, six lines. Height of pelvis, three lines; height of superior plates, five lines.

The column is undiscovered.

This is one of the most beautiful species with which we are acquainted. It was obtained from the quarries in the carboniferous limestone at Burlington, where it is exceedingly rare.

DICHOCRINUS STRIATUS. (N. S.)

(Tab. V. A, fig. 10, *a*, *b*.)

Body globose, and composed of thin plates.

Basal plate hexagonal, bi-partite, hemispherical, superior margin undulating; circle of attachment for the column small, slightly excavated, finely striated in radii, with a minute round perforation in the centre. The surface is marked with permanent thread-like striæ, some of which begin at the excavation, others originate near the middle of the plate, and radiate to the superior margin.

Superior plates six, five of which bear the arms; these are quadrilateral, somewhat elongated, wider inferiorly than at the summit, with the articulating surface for the arms, as in the preceding species, situated on their superior edges. The non-ray-bearing plate is trapezoidal, wide, slightly angular at the base and narrow above. The striæ on this series of plates range in lines parallel to the lateral borders, and join those in the basal plate. Some of the striæ are bifurcated near the upper margin, and when examined with a lens, have an undulated appearance. The furrows between the striæ are crossed at irregular intervals by transverse threads.

Formation and localities.—Occurs at Burlington in the encrinital layers of the carboniferous limestone, immediately above the oolitic members. It is not an abundant species.

GENUS CYATHOCRINUS. *Miller.*

CYATHOCRINUS IOWENSIS. (N. S.)

(Tab. V. A, fig. 11, *a*, *b*, *c*.)

Body globose. *Basal plate* rather small, pentagonal, composed of five plates, closely adhering among themselves, flattened, with a small hemispherical cavity for the insertion of the column, having a small round perforation in the centre; superior angles bent slightly upwards. *First series* of perisomic plates five, of which four are pentagonal, inclining, however, to a subhexagonal form; and one hexagonal. These plates are somewhat massive and tumid in their centres. The *second series* is composed of six plates, five are pentagonal, support the arms and rest on the oblique upper edges of the first series; the sixth, which is hexagonal, is placed on the superior truncated edge of the hexagonal plate of the first series, and supports on its upper edges three small irregular plates. The articular facets for the attachment of the arms are horseshoe-shaped, moderately large, concave, and have a deep angular notch superiorly. The external surface of all the plates which compose the body are finely corrugated, giving to the species a very neat appearance.

Column, arms, and abdominal plates unknown.

Formation and localities.—It occurs at Burlington, Iowa, in the carboniferous limestone, whence we have been so fortunate as to obtain several specimens. We are not aware of its having been found elsewhere.

CYATHOCRINUS CORNUTUS. (N. S.)

(Tab. V. A, fig. 8, *a*, *b*.)

Basal plate small, pentagonal, composed of five subrhomboidal plates, firmly adhering among themselves; flattened or slightly concave, with a small pentapetalous central perforation. First series of perisomic plates five, four of which are pentagonal and one hexagonal. Each plate is lengthened into a process approaching to a conical form, which projects downwards and outwards for some distance below the plane of the basal plate, so that when a side view of the visceral cup is taken, this plate is not visible. The second series consists of six massive plates, of which five support the arms, and rest by their lower salient angles in the re-entering angles formed by the union of the first series. The arm-bearing plates are conical in their centres, and present, at their superior edges, a large bevelled surface, which is somewhat of a semilunar shape, and slightly concave for the insertion of the arms.

Column, arms, and abdominal plates undiscovered. It is associated with the preceding species at Burlington, where it is exceedingly rare; only a single specimen having rewarded our search.

GENUS PENTREMITES. *Say.*

PENTREMITES* NORWOODII. (N. S.)

(Tab. V. A, fig. 13, *a*, *b*, *c*.)

The general form of this species is globose, and the whole surface between the so-called ambulacral spaces is thickly studded with small granulæ, very regularly arranged in longitudinal rows. At the base a profound funnel-shaped cavity is observable.

The *basal plate* (pelvis) is small and lines about one-half of this funnel-shaped cavity, at the apex of which is a small circular impression for the insertion of a column. This pelvis is composed of three pieces, two pentagonal and one trapezoidal.

Costals five; elongated, equal, extending along the whole height of the body, bent upwards inferiorly to articulate with the pelvic plates in the funnel-shaped cavity. The summit of each plate is obliquely truncated on both sides of the ambulacra, so that when these plates are united together, five re-entering angles are formed, in which rest the inferior salient angles of the superior plates. A longitudinal medial

* It is probable that this and the following species will constitute a new genus.

ridge extends over each plate, and projects a little below its base. These ridges, which are more prominent inferiorly than superiorly, and wider from below upwards, receive the five ambulacra. Each of the ambulacra is divided into two equal parts by a longitudinal furrow, and each part is composed of a double series of minute, elongated, subhexagonal plates, articulating among themselves by a line of alternately salient and retreating angles. The number of little plates in each of the above spaces, amounts to about two hundred. These articulations are bounded externally by a longitudinal gutter, at the bottom of which a series of minute pores are perceptible by the aid of a good lens. The pores probably served for the transmission of small brachial ligaments, by which the delicate arms attached to their margins were set in motion.*

Superior plates small, lanceolate, each one with a mammillary projection near the inner angle, perforated at the summit by a minute rounded opening.

It occurs in the subcarboniferous limestone at Burlington and Augusta, Iowa, and Oquawka, Illinois. We dedicate this elegant species of Pentremite to our highly esteemed and gifted friend and co-labourer, Dr. J. G. Norwood, of Madison, Indiana.

PENTREMITES MELO. (N. S.)

(Tab. V. A, fig. 14, *a*, *b*, *c*.)

The form of this Pentremite is globular, sometimes slightly elongated, and the surface is ornamented with minute granulæ, very regularly arranged in longitudinal rows as in the *P. Norwoodii.*

Basal plate small, pentagonal, flat or slightly concave, composed of three pieces, two are broad pentagonal, and one is rhombic. The articulating surface for the column, which is round and equal to one-half the diameter of the plate, is finely striated on the margin, and exhibits a minute central perforation. The external edges of the plate are slightly concave, to accommodate the inferior rounded edges of the perisomic plates (costals of Miller).

These latter are of an elliptical form, convex, and project inferiorly a little below the plane of the basal plate, while their summits are truncated on both sides of the ambulacra for articulating with the superior plates. Their union is strongly marked by a deeply indented longitudinal furrow. The ambulacra are narrow, and widen slightly from below upwards; they commence from a half to three-quarters of a line above the basal edge of the plates, and are continued a little beyond their superior margins, being more deeply inserted into the ambulacral gutter superiorly than inferiorly. The ambulacra are composed of numerous small plates, arranged as in the *P. Norwoodii;* these are marked on the edges by fine striæ, which are perceptible only by the aid of a good lens.

Superior plates small, elongated, symmetrical, composed at the base of a truncated triangle, surmounted by an irregular hexagon. The inferior lateral edges of the hexagon in four of these plates are notched, so that when united to the contiguous ambulacra eight pores are formed, surrounding the summit. The fifth superior plate is perforated with an oval opening—the vent—which is much larger than the above-mentioned pores.

It occurs in the subcarboniferous limestone at Burlington, Iowa, where it is rather abundant. We have not observed it at any other locality.

Dimensions.—Height, 6·5 lines; width, 6 lines; diameter of pelvis, 1·5 lines; length of perisomic plates, 6 lines; width of perisomic plates, 3 lines.

PENTREMITES LATERNIFORMIS. (N. S.)

(Tab. V. A, fig. 15.)

Of this species we possess only a siliceous mould of the interior, and it may hereafter, when more perfect specimens are found, originate a new genus; for the present, however, we will not separate it from the Pentremites.

* Among a number of specimens of *Pentremites florealis* (Say), procured by J. Evans at Chester, Illinois, we have found one, in which the arms still remain attached, and lie folded in the ambulacral spaces. These arms are extremely delicate, and originate at the so-called pores of the ambulacra. They are composed of small plates arranged in longitudinal series, as in the true Crinoids. None of them bifurcate, and we have not been able to observe any traces of tentaculæ. In the specimen the five apertures at the summit are completely closed by a conical abdominal integument, made up of small microscopic pentagonal plates.

It presents somewhat the appearance of a street lamp, its lower portion having the form of a truncated pentagonal pyramid inverted, while its upper part is dome-shaped.

The *basal plate* is composed of three pieces, two are widened pentagons, and one is a rhomb; united together, they form an irregular octagon with three obtuse re-entering angles, to the points of which the basal sutures radiate.

Perisomic plates five, elongated; their length being to their breadth about as one to two; three of them terminate inferiorly in an obtuse salient angle, each angle corresponding to one of the retreating angles formed by the union of the basal pieces, two terminate below in a straight edge, and rest on the superior margins of the pentagonal basals. A triangular fold projects exteriorly from the superior portion of each plate. The apex of this triangle points downwards and extends nearly to the middle of the plate. These folds are notched superiorly for the reception of the five radiating ambulacra, and a portion of the superior plates, and on either side is a short, straight edge.

The *superior plates* are dart-shaped, the barbs being inserted into the triangular notch on either side of the ambulacra, while the intervening edges rest on the corresponding straight margins of the perisomic plates included between the folds. The point of the dart terminates at the apex of the fossil. The ambulacra widen slightly from below upwards.

This *Pentremite* was obtained from the carboniferous strata on Mill Creek, Randolph County, Illinois, about seven miles from Chester.

PENTREMITES STELLIFORMIS. (N. S.)

(Tab. V. A, fig. 16, *a*, *b*.)

The body of this Pentremite is much less elongated than the preceding species, and its diameter is proportionally greater. It is moderately convex at the summit and depressed conical below.

Basal plate pentagonal, depressed subconical, slightly constricted near the middle by a circular depression, and composed of three pieces, two pentagonal and one quadrilateral: the upper edges are nearly straight, and support the five perisomic plates.

The perisomic plates are short and much elevated in the centre, each plate being in fact a four-sided pyramid rounded at the angles, and having its apex projecting exteriorly. These plates increase slightly in width from below upwards, and their superior margins are obliquely truncated on both sides of the ambulacra for the reception of the superior pieces. The surface is covered with fine striæ, running parallel to the lateral and inferior borders. These striæ are so fine that they are scarcely perceptible to the unassisted eye. The union of these pieces forms at the summit a decagon, very regular, in which five angles are salient and five retreating. Five radiating petalloid ambulacra commence at a central stelliform space, and terminate near the tips of the salient angles of the decagon. Each of the ambulacra are divided into two parts by a median furrow, and each part is made up of a great many small articulations, the form and arrangement of which cannot be determined in our specimen.

The *superior plates* are small and lie nearly horizontal: four of them are elongated, eight-sided and irregular; the fifth is larger than the rest, and composed of two pieces of an irregular form united together transversely, and perforated by an oval opening at the suture.

This neat and elegant Pentremite occurs with various other crinoidal forms in the subcarboniferous limestone at Burlington, Iowa. It is rare, the specimen figured being the only one that we have discovered.

ACTINOCRINUS UNICORNUS. (N. S.)

(Tab. V. A, fig. 12, *a*, *b*.)

General figure depressed, subconical below the insertion of the arms, convex at the summit.

Basal plate tripartite, somewhat massive, suboctagonal, bordered by a rim more or less elevated, its continuity interrupted by three triangular notches. Six somewhat massive plates, tumid in the centre, surround the basal plate, five are hexagonal, and one is irregular and heptagonal. The second series consists of twelve pieces, five are quadrangular, short (their height being to their breadth as one to two), slightly arcuated on their edges, and rest on the upper edges of the hexagonal plates of the first series; four are nine-angled, one being situated between each pair of quadrangular plates, and their inferior salient

angles are inserted in the retreating angles formed by the union of the hexagonal plates of the first series; two are irregularly heptagonal, and one hexagonal: these repose on the upper edges of the heptagonal plate of the first series. Each of the above-mentioned quadrangular plates is surmounted by a widened pentagonal plate, which again supports on its oblique upper edges two short irregular pieces, sub-hexagonal or pentagonal, with their superior margins slightly concave to accommodate the arm-bearing plates, which are small and somewhat horseshoe-shaped. All the pieces which we have mentioned above the basal plate are elevated in their centres, which gives to the surface of the visceral cup an uneven appearance.

The *coronal integument* is made up of numerous polygonal plates. The central one is a little larger than the rest, and is garnished with a spinous process, which is often produced to half an inch in length; the others are usually tumid in their centres and wrinkled; in some specimens, however, they are furnished with projecting tubercles, some of which are flattened and divided into two or more points.

Mouth sub-central, protrusive but not proboscidiform. It is situated near the inner extremity of a prominent ridge composed of small, irregularly-shaped plates. This ridge commences at the central spinous plate, and terminates at the outer border of the cup between two of the arms.

Arms twelve, bifurcations unknown. *Column* undiscovered.

It occurs rather abundantly in the subcarboniferous limestone at Burlington and Augusta, Iowa.

MEGISTOCRINUS. (N. G.)

Generic character.—Basal plate tripartite, hexagonal, divisions equal. *First series* of plates six, five hexagonal, and one pentagonal; *second series* thirteen, hexagonal; *third series* nineteen, five pentagonal, eight hexagonal, six heptagonal. These are surmounted by six ranges of polygonal plates, each range becoming successively smaller, and the plates more numerous in the ascending order. *Coronal integument* composed of numerous polygonal plates. *Proboscis* a little below the superior rim, short and slender.

MEGISTOCRINUS EVANSII. (N. S.)

(Tab. V. A, fig. 3, *a*, *b*.)

Synonym.—Actinocrinus Evansii, vol. ii., part i., p. 68, Jour. Acad. Nat. Sci.

Specific character.—The body of this fine species has the form of an inverted truncated cone, with a moderately rounded base. Basal plate large, somewhat massive, flattened, slightly concave near the margin, moderately convex towards the centre. Impression for the attachment of the column large, occupying nearly one-half the diameter of the plate, slightly excavated and striated on the margin, perforation large, obscurely pentagonal. First series of plates large, moderately convex, bent inwards and slightly upwards near their inferior margins, projecting below the plane of the basal plate, and not visible on the side view of the fossil. All the plates forming the sides of the cup are smooth, and slightly convex on the surface. Coronal slightly elevated, pieces of various dimensions, the larger ones mammillated in the centre.

Proboscis short and slender; column and arms unknown.

Dimensions.—Height, twenty-five lines; width at summit, thirty-two lines; width at base, thirteen lines; diameter of basal plate, seven lines.

Formation and locality.—It occurs with the preceding species in the lower series of carboniferous limestone at Burlington, Iowa. For the magnificent specimen figured we are indebted to John Evans of the United States Geological Corps, and to him we have dedicated it.

PLATYCRINUS. *Miller.*

PLATYCRINUS AMERICANUS. (N. S.)

(Tab. V. B, fig. 1, *a*, *b*.)

Calyx.—Subglobose, surface ornamented with numerous prominent granulæ. *Basal plate* pentagonal, flattened; surface for the attachment of the column small, round, finely striated in radii, with a minute central perforation. From the edge of this surface five principal rows of granulæ radiate to each angle of the plate, the intervening spaces being likewise granulated. *Superior plates* five, rather broad, increasing slightly in width from below upwards; articular facet for the arms small and shallow. The granulæ are usually disposed over the surface of these plates, as follows: a row commences at each of

the inferior angles, and terminates at the base of the arms, marking out three triangular spaces on each piece, which are also studded with granulæ.

This encrinite is nearly allied to *Platycrinus granulatus* (Miller), but it can be readily distinguished from that species by its more depressed form, smaller size, and flattened basal plate.

Formation and locality.—It occurs in the quarries near Burlington, Iowa, in the encrinital beds of the carboniferous limestone, just above the oolitic members of this formation. It is associated with *Spirifer striatus, Orthis Michelini, Productus punctatus,* and other carboniferous forms.

EXPLANATION OF FIGURES.

Fig. 1, *a.* View of the base of the calyx.
" *b.* Side view.

POTERIOCRINUS. *Miller.*

POTERIOCRINUS RHOMBIFERUS. (N. S.)

(Tab. V. B, fig. 2, *a, b, c.*)

Calyx.—Conical, plates massive, surface garnished with heavy ridges. *Basal plate* pentagonal, small, scarcely a line in diameter, entirely concealed from view when the supra-columnar joint remains attached.

First series of pieces five, pentagonal, or irregularly hexagonal, forming by their union a shallow cup, with a decagonal margin, in which five of the angles are salient, and five re-entering. *Second series* five, three hexagonal and two heptagonal, resting by their inferior salient angles in the retiring angles of the plates beneath, and supporting on their oblique superior edges, the five superior or arm-bearing plates, and two accessory pieces. The *superior pieces* are larger and more massive than the plates beneath; their width is about one-third greater than their length, and each presents a large bevelled surface at the superior margin for the articulation of the arms. This surface is moderately excavated, and occupies about four-fifths of the entire width of the plate. *Accessory pieces* two in number: one small and quadrangular, rests in a retreating angle between the heptagonal plates of the second series, the other irregularly pentagonal, is wedged in between two of the arm-bearing pieces.

The surface of the calyx of this species is marked by heavy ridges, five of which commence on the first series of plates, and crossing the sutures, bifurcate on the second series; the branches then proceed to the superior pieces, where they again unite with each other, in such a manner as to form a series of five lozenge-shaped figures around the body, enclosing as many shallow depressions.

Column, arms, and capital integument unknown.

It occurs with *Platycrinus discoideus, Pentremites melo, P. stelliformis,* and other fossil remains in the encrinital beds of the carboniferous limestone at Burlington, Iowa.

For the fine specimen figured we are indebted to Dr. Matthews, of Burlington, who obligingly furnished us with a number of interesting Crinoids from his choice collection. We have not observed it elsewhere in the Northwest.

EXPLANATION OF FIGURES.

Fig. 2, *a.* Basal view.
" *b.* Side view, exhibiting the two accessory pieces.
" *c.* View of the side, showing the form of the superior plates.

POTERIOCRINUS TUMIDUS. (N. S.)

(Tab. V. B, fig. 3, *a, b.*)

Calyx.—Subovate, rapidly enlarging from a narrow base to the summit, tumid in the middle, plates smooth, slightly convex, moderately thick, column round, very slender. *Basal plate* concealed. First series of plates small, pentagonal, closely adhering among themselves, forming when united a little cup; its superior edge with five obtusely salient, and five very slightly re-entering angles. *Second series* five, three hexagonal and two heptagonal, their height nearly four times that of the first series, bent a little

inwards superiorly; inferior angles slightly salient. *Superior plates* unknown. Of the *accessory pieces*, one plate only remains: this is nearly square, and is placed between the two heptagonal plates of the second series.

Column very small, consisting of round joints, with articulating surfaces striated in radii.

Dimensions.—Height of first series, 1 line; of second series 3·5 lines; greatest width of calyx, 5 lines; diameter at base, 2 lines.

From the imperfect condition of the only specimen we have seen of this species, its characters cannot be well determined; the description given above, however, will enable any one to identify it without difficulty.

It was found in the pentremital layers of the carboniferous limestone at Chester, Illinois, associated with *Pentremites florealis, P. Cherokeus, Agassizocrinus dactyliformis,* and *Productus Flemingii.*

EXPLANATION OF FIGURES.

Fig. 3. *a.* Basal view.
" *b.* View of the side.

POTERIOCRINUS SPINOSUS. (N. S.)

(Tab. V. B, fig. 4.)

Calyx.—Cup-shaped, small; plates smooth; mouth proboscidiform; arms five; subdivisions thirty, furnished with thorn-like projections at the points of bifurcation. *Basal plate* pentagonal, small, slightly concave, with a minute pentagonal opening in the centre; divisions of the plate not perceptible. *First series* of plates pentagonal, small, thin. They surround the basal plate, and form by their union a little pentagon, flat or slightly concave, which is almost completely hidden from view by the last joint of the column, so that, in order to obtain a good view of them, it is necessary to remove this portion of the animal. The *second series* consists of five pieces, three pentagonal and two hexagonal; they are larger and more massive than the plates beneath; surface moderately convex, inferior margins bent inwards to articulate with the plates of the first series. *Superior* or *arm-bearing plates,* wide, pentagonal, thick, moderately convex; facet for the articulation of the arms, wide, situated on the upper edge of the plates, occupying their entire breadth. *Accessory pieces* three, irregular.

The surface of the calyx exhibits a number of small indentations, one of which is situated at each of the angles of the second series of superior, and accessory pieces.

Main arms five, each composed of a single joint, which is irregular, elongated and furnished with a thorn-like projection superiorly. The upper edge presents two oblique facets, supporting two hands, consisting of wedge-shaped joints, arranged in single longitudinal series. The number of joints in the different hands varies from eight to ten. The superior ones are spinous, and each supports two fingers, one of which continues without further division to the summit, the other bifurcates several joints above its origin.

Proboscis long and slender, surmounted by three plates of a conical figure, joined together at their bases.

Column unknown.

The specimen figured was obtained from the Archimedal layers of the carboniferous limestone of Kaskaskia, Illinois. It there occurs with *Terebratula plano-sulcata, T. Roissyii, Pentremites florealis, P. pyriformis, P. Cherokeus* (Troost), and *Poteriocrinus* (*Zeacrinus*) *magnoliaformis* (Troost). It occurs also in a similar geological position in Grayson County, Kentucky, where it was discovered by Dr. L. P. Yandell, whose fine collection of Crinoids contains a very perfect specimen of this interesting species.

POTERIOCRINUS OCCIDENTALIS. (N. S.)

(Tab. V. B, fig. 5, *a, b.*)

Calyx.—Cup-shaped, increasing from the base to the summit, swelled in the middle; transverse section nearly circular; plates somewhat massive, smooth, slightly convex. *First series* of plates five, irregularly pentagonal, closely adhering among themselves, bent upwards below to form the sides of a funnel-shaped

cavity, at the bottom of which is situated the *basal plate;* inferior edge very short, lateral edges straight; superior angles obtuse: in their connexion they form a pentagon with straight or slightly concave edges. *Second series* five, longer than wide, and more than double the size of those of the first series, smooth, moderately convex; three are pentagonal, and two irregular and hexagonal, resting by their edges on the superior edges of the first series. *Superior plates* pentagonal, short, width about double the length; inferior angles obtuse; lateral edges straight, superior edges slightly concave; facets for the arms nearly equal to the entire width of the plates. *Accessory pieces* three, irregular, one oblong quadrangular, two sub-pentagonal. The quadrangular plate is larger than the rest, and its superior angle is truncated to support one of the smaller accessory pieces. A few joints of the *arms* are preserved in the only specimen we have found of this species, viz.: a single brachial piece, which is pentagonal and slightly arcuated on the lateral edges; on its oblique upper edges rests the commencement of a double series of hand joints, consisting of wedge-shaped pieces.

The *column* has not been discovered; judging, however, from the small impression on the calyx, it must have been very slender in comparison with the size of the body.

It occurs at Chester, Illinois, where it occupies a similar geological position to the preceding species.

EXPLANATION OF FIGURES.

Fig. 5. *a.* Side view, showing the form of the accessory pieces, and a few of the joints of the arms remaining attached.
" *b.* Basal view.

GENUS AGASSIZOCRINUS. (*Troost* in MS.)

AGASSIZOCRINUS CONICUS. (N. S.)

(Tab. V. B, fig. 6.)

Calyx.—Elongate-conical; plates massive; surface smooth; internal cavity small. Column none.

Basal plate conical, rounded at base, exhibiting no marks for the insertion of a column; sides slightly convex, consisting of five pieces, closely adhering among themselves, frequently anchylosed; length rather more than half the entire height of the calyx; superior edge with five slightly bevelled facets, on which repose the first series of pieces. *First series,* five, pentagonal, thick, very slightly convex, length and breadth about equal. *Superior pieces* five, pentagonal, wide, and very short; upper edges straight.

Arms unknown.

It occurs with *Agassizocrinus dactyliformis* and *Pentremites florealis,* in the subcarboniferous limestone at Chester, Illinois.

SYNBATHOCRINUS DENTATUS. (N. S.)

(Tab. V. B, fig. 7, *a*, *b*.)

Calyx.—Conico-cupuliform; plates massive; surface smooth; internal cavity small, occupying less than half the diameter of the body; arms five; column round; alimentary canal pentalobate.

Basal plate saucer-shaped, pentagonal, tripartite; two of the pieces are wide pentagonal, and one has the figure of a trapezium; superior edges slightly concave; impression for the column equal to about half the diameter of the plate, circular, slightly excavated, striated on the margin; central perforation small, pentalobate. *Superior plates* five, sub-quadrangular, widest above; upper edge straight or slightly concave, furnished at their internal margins with two triangular tooth-like elevations, which form abutments for the arms and prevent their displacement internally; articular facets for the arms large, occupying the entire breadth of the plates.

It occurs rather abundantly in the encrinital beds of the subcarboniferous limestone at Burlington, Iowa.

The basal plate of the genus *Synbathocrinus* is described by Austin as being undivided. (Monograph. Recent and Fossil Crinoidea, page 93.) We are convinced, however, from an examination of numerous specimens from Kentucky, Indiana, Iowa, and Tennessee, that this is an error. In all well-preserved specimens we have found the basal plate to consist of three pieces.

The species resembles in some respects *Synbathocrinus conicus* (Phillips), but is easily distinguished by the larger size of its basal plate, and the shortness of its superior plates. From the description of *Synbathocrinus Tennesseeæ* (Troost in MS.), it differs in several important characters, and occupies a different geological position.

EXPLANATION OF FIGURES.

Fig. 7. *a.* Basal view, showing the tripartite character of the basal plate.
" *b.* View of the side, exhibiting the dental elevations on the superior edges of the arm-bearing plates.

ARTICLE III.

SUMMARY OF THE DISTRIBUTION OF ORDERS, GENERA, AND SPECIES, IN THE NORTHWEST.*

ORDERS.	LOWER SIL.		UPPER SIL.		DEVONIAN.		CARBONIF.		TOTAL.	
	Species.	Genera.	Species.	Genera.	Species.	Genera.	Species.	Genera.	Species.	Genera.
Crustacea (Trilobites)	28	12			2	1	3	1	33	14
Crinoidea, . . .	2	2			3	3	24	9	29	14
Cephalopoda, . .	19	8					2	2	21	10
Gasteropoda, . .	20	8			1	1	1	1	22	10
Heteropoda, . .	3	2			1	1	1	1	5	4
Pteropoda, . . .	2	1					1 ?		3	1
Acephala, . . .	8	4	1	1			6	4	15	9
Brachiopoda, . .	39	8	8	4	34	8	43	5	124	25
Foraminifera, . .	2	1					1	1	3	2
Polyparia. . . .	1	1	11	11	22	11	12	6	46	21

THE GENERA OF BRACHIOPODA ARE DISTRIBUTED AS FOLLOWS:

GENERA.	LOWER SIL. Species.	UPPER SIL. Species.	DEVONIAN. Species.	CARBONIF. Species.	TOTAL. Species.
Spirifer, ...	1	2	9	12	24
Orthis, ...	12		5	4	21
Leptæna, ...	15		1		16
Strophodonta, . . .			6		6
Chonetes, ...			4	4	8
Productus, ...				16	16
Pentamerus, . . .		2	1 ?		3
Terebratula, . . .	1 ?	1	2	8	12
Atrypa, ...	3		6		9
Obolus, ...	1				1
Lingula, ...	5	2			7
Orbicula.	1				1
Total Brachiopoda.	39	7	34	44	124

Of the species found in the beds of the Northwest, from the top of the upper magnesian limestone to the base of the lowest sandstone, twenty-three have been identified with forms occurring in the Lower Silurian strata of Europe. The following characterize the inferior system of both countries:—*Leptæna sericea, Leptæna alternata, Orthis testudinaria, Spirifer biforatus, Lingula quadrata, Pentamerus oblongus, P. lævis, Porcellia ornata, Pleurotomaria lenticularis, Obolus Appolinis, Isotelus gigas, Illænus crassicauda, Ceraurus pleurexanthemus,* and *Chætetes lycoperdon.* The remainder correspond with species of the Wenlock formation, several species, however, being common to it and the Devonian system. They are:—*Catenipora escharoides, Favosites gothlandica, Favosites spongites, Porites pyriformis, Atrypa reticularis, Terebratula Wilsonii, Leptœna depressa, Spirifer trapezoidalis,* and *Pentamerus galeatus.*

As might be expected, a much larger number corresponds with species occurring in the equivalent beds of New York, Ohio, Kentucky, and Tennessee. At least forty-six have proved to be identical with species

* Modified by additions and researches since the publication in the Proceedings of the American Association, 1851.

ranging between the Potsdam sandstone and the Niagara limestone; thirty-seven of which may be referred to species distributed through the Trenton limestone, Utica slate, and Hudson River group, as follows:—*Chætetes lycoperdon, Conularia Trentonense, Ambonychia undata, A. amygdalina, Nucula levata, Bellerophon bilobatus, Pleurotomaria lenticularis, P. subconica, P. umbilicata, Subulites elongata, Murchisonia subfusiformis, M. bellicincta, M. tricarinata, Cytoceras macrostomum, Orthoceras vertebrale, O. laqueatum, O. junceum, Leptæna planumbona, L. alternata, L. sericea, L. deltoidea, Atrypa hemiplicata, A. modesta, A. capax, Spirifer biforatus, Orthis testudinaria, O. tricenaria, Lingula quadrata, Echino-encrinites anatiformis, Heterocrinus heterodactylus, Calymene senaria, Isotelus gigas, Illænus crassicauda, Ceraurus pleurexanthemus, Phacops callicephalus,* and *Lichas Trentonensis.*

One species, *Gonioceras anceps*, is peculiar to the Black River limestone: one, the *Orthoceras multicameratum*, to the Bird's eye limestone; and one, *Maclurea magna*, to the Chazy limestone.

Four appertain to the Clinton and Niagara groups:—*Pentamerus oblongus, Atrypa reticularis, Leptæna depressa, Catenipora escharoides.*

Among the species from the Devonian rocks on the Upper Mississippi, between Parkhurst and New Buffalo, and at the other localities in the Northwest, more than two-thirds are identical with species occurring in the shell and coralline beds of the Falls of the Ohio, in the vicinity of Louisville, and Charleston landing, Indiana.

The Onondaga limestone and Hamilton group of New York are represented by the following species:—*Leptæna depressa, L. inequistriata, Atrypa reticularis, A. concentrica, A. aspera, Spirifer macronotus* (?), *S. mucronatus* (?), *S. congesta, Pleurorhynchus trigonalis, Phacops crassimarginata, P. macrophthalma,* and *Favosites gothlandica.* This list will doubtless be greatly extended, when the forthcoming volumes on the palæontology of the higher rocks of the New York system appear, as they will afford means of comparison between the fossils of the two districts, not now at our disposal.

Thirteen species are identical with European forms, as follows:—*Lucina proavia, Spirifer heteroclytus, Atrypa reticularis, A. aspera, A. concentrica, Orthis resupinata, O. umbraculum, Chonetes nana, Phacops macrophthalma, Astræa ananas, A. hexagonum, Stromatopora polymorpha, Favosites gothlandica,* and *Favosites polymorpha.* Of these, several belong exclusively to the Devonian strata in that country, while some extend downwards into the Silurian, and some above into the Carboniferous beds.

Of the one hundred and twenty Carboniferous species collected chiefly in the State of Iowa, twenty-four are European species; these are—*Chætetes capillaris, Lithostrotion floriforme, Conularia quadrisulcata, Chonetes variolata, Orthis umbraculum, O. Michelini, O. resupinata, Terebratula plano-sulcata, T. lamellosa, T. Roissyii, T. sacculus, Productus punctatus, P. cora, P. Flemingii, P. costatus, P. semireticulatus, P. carbonarius, Spirifer striatus, S. cuspidatus, S. lineatus, S. rotundatus, Fusulina cylindrica, Platycrinus granulatus,* and *Poteriocrinus plicatus.*

It is remarkable, that, while more than one-half of the Brachiopoda of this system can be referred to European species, only two out of the fifty-two Crinoids (described and undescribed), have been recognised as common to the two countries.

From the foregoing, it appears, that the Brachiopoda of these western palæozoic groups embrace the greatest variety of species: the Silurian period furnishing the greatest number of this order; the Carboniferous next; while the Devonian rocks have as yet supplied the fewest. This is partly to be accounted for, however, from the limited area over which this latter group of rocks is accessible. The Crinoidea rank next to the Brachiopoda, in the abundance of species; about nine-tenths of these are from beds of the Carboniferous age.

Next to the Crinoidea, in numerical importance, come the Crustacea; this order being by far the most numerous in the Silurian period, which has furnished four-fifths of the whole number of species. The Cephalopoda and Gasteropoda are next most abundant; the latter system affording the greatest amount of species.

The Polyparia, on the other hand, appear to be most abundant in the Devonian rocks; indeed, some of these beds, in Iowa, are made up almost entirely of corals. The Acephala appear to be most abundant in the Silurian and Carboniferous rocks. Only two or three species of Pteropoda have as yet been found, two of which appear in the Silurian rocks, and one in the carboniferous, which formations have afforded the only species of Foraminifera yet obtained.

If we may judge from the abundance of coralloid limestones in the Devonian period, and the purity of these calcareous beds, with little siliceous and argillaceous intercalations, we are perhaps justified in con-

cluding, that the ocean, during that epoch, was both shallow and clear. It is also worthy of note that the coral formations of the Devonian period, in the valley of the Ohio, Mississippi, and Red Cedar Rivers, are found at localities where the streams form rapids, or low falls; from which it appears probable, that the Polyparia have erected their structures on submarine ridges of the Devonian seas, formed by the principal anticlinal axes existing at that geological epoch.

ARTICLE IV.

ADDITIONAL CHEMICAL EXAMINATIONS BY D. D. OWEN.

ANALYSIS OF TWO MINERALS AND NOTICE OF A NEW EARTH. ?*

While examining, in the summer of 1848, the north shore of Lake Superior, situated in Minnesota, between Pigeon Point and Fond du Lac, particularly in the vicinity of Baptism River, I observed a peculiar, soft, green mineral, diffused in the amygdaloidal traps. Though not in large masses, this mineral was so abundantly disseminated in some of these rocks that the least blow of the hammer indented the rock and left a whitish-green mark from the easily crushed particles of the soft green mineral in question.

In the winter of the same year I undertook a chemical analysis of the mineral, and repeated it on several varieties in the year following.

The result showed it to be essentially a hydrated silicate of magnesia, and what appeared to be a new earth, intermediate in its properties between magnesia and manganese.

The colour of this mineral when pure is of a pale yellowish green; consistence and hardness about that of wax. Heated in a matrass it gives off water. Heated strongly alone in the forceps it whitens, but does not exfoliate; tinges the outer flame slightly green. In thin splinters it fuses on the edges. With borax it dissolves with difficulty into a transparent bead, which has a greenish tinge when hot. With soda it dissolves but very partially and very slowly. Heated with nitrate of cobalt, hardly any colour is perceptible. Fused with four times its weight of carbonate of soda and potash in a platina vessel it gives a white enamel, tinged on the edges only of a light blue. Some specimens of this mineral effervesce distinctly with acids; but this is always from impurities. The pure varieties contain no carbonic acid. Specific gravity, 2·548. It has not been found crystallized.

Treated with hydrochloric acid, chlorine is evolved, and the greater part of the constituents, except silica, dissolved.

After the separation of the silica and the greater part of the magnesia, there invariably remained a whitish mass, tinged slightly of a reddish-yellow or flesh-colour, which had a tendency to darken in the air: this amounted to 18 or 19 per cent. When this was dissolved in just sufficient hydrochloric acid to take it up, and afterwards boiled with excess of caustic potash, 4·6 per cent. of alumina separated, leaving about 13·5 of matter quite insoluble in that reagent; of this 1·5 per cent. was peroxide of iron, and about 12 per cent. the new earth above alluded to, contaminated with some magnesia, which had escaped solution in the excess of chloride of ammonium employed to remove it.

The composition of the mineral is therefore as follows:

$\dot{H}$—Water,	18·
$\dddot{Si}$—Silica,	42·
$\dot{Mg}$—Magnesia,	20·5
New earth, with some Mg. not taken up by sal. amm.	10 to 12
$\underline{\dddot{Al}}$—Alumina,	4·6
$\underline{\dddot{Fe}}$—Peroxide of iron,	1·5
$\dot{K}$—Potash,	0·8
Mn,	a mere trace.

* Originally published in the Journ. A. N. S. 2d Ser. Vol. II. pt. 2, Jan., 1852.

It was found exceedingly difficult to free this earth entirely from oxide of iron and magnesia. I succeeded, however, in separating the iron by the following process, so that the solution no longer gave the reaction indicative of iron either with hydrosulphuret of ammonia or ferro-prussiate of potash. The solution was evaporated nearly to dryness, and while still hot a jet of water was thrown on it. By repeating this process several times the oxide of iron was all precipitated, and could be separated by filtration, though the solution passed with extreme slowness through the filter from the fine state of the precipitated oxide of iron. The magnesia was separated by two methods, either by dissolving the earth in hydrochloric acid, adding sal ammoniac and neutralizing with ammonia, or, by digesting the earth in water acidulated with a few drops of nitric acid. In consequence, however, of the new earth being slightly soluble in sal ammoniac and in dilute nitric acid, some loss is sustained by this method, and therefore it is not applicable to quantitative analysis.

When thus separated, this earth has the following properties and reaction with reagents.

It dissolves readily either in hydrochloric or nitric acid, evolving chlorine from the former acid. The solution in hydrochloric acid, when concentrated, has a beautiful pea-green colour, and the salt crystallizes either of a slightly paler green or a light chrome yellow, depending on the degree of heat at which the evaporation is completed. The peculiar colour of its salts, together with the appearance of the residue left in the analytical process after treating with caustic potash to separate the alumina, was what first attracted my attention to this earth.

The solution of the earth in dilute hydrochloric acid gives the following reactions with reagents:

Ammonia, a white, bulky precipitate, only sparingly soluble in sal ammoniac. This is one of the characters which distinguish it from magnesia.

Oxalate of ammonia, a white precipitate in neutral solutions: another distinction between it and magnesia.

Oxalic acid, no precipitate until quite neutralized by ammonia.

Bicarbonate of potash, white precipitate; apparently slightly soluble in excess.

Phosphate of soda and ammonia; the vesicular precipitate with this reagent is quite peculiar, and forms one of the marked characteristics of this earth. If the reagent be added without disturbing the fluid, a number of little vesicles are formed, which remain distinct, as if each were enclosed in a delicate translucent membrane.

Ferrocyanide of potash, a white precipitate, with a slight tinge of bluish green, which seemed to be independent of any remaining trace of oxide of iron; perhaps in part due to the colour of the reagent itself.

Hydrosulphuret of ammonia, a white precipitate.

Succinate of ammonia, a white precipitate, even in slightly acid solutions.

Benzoate of ammonia, the same, with a tinge of yellow.

Crystals of sulphate of potash inserted in the solution gave but a very slight precipitate, and that only after long standing.

The precipitate of phosphate of soda is only soluble in a considerable portion of muriatic acid, and is not precipitated by boiling.

When separated, and still slightly contaminated with magnesia, the earth has a pale flesh-colour, not unlike yttria. When freed from the magnesia, it has more the appearance of powdered, dried albumen.

The earth differs from alumina and glucina in being insoluble in caustic potash.

From magnesia, in producing coloured salts; in being only slightly soluble in ammoniacal salts; in the peculiar vesicular character of the precipitate with phosphate of soda; in being precipitated by oxalate of ammonia.

From yttria it differs in not giving a precipitate with oxalic acid in slightly acid solutions; in being precipitated by succinate of ammonia, even before the solution is quite neutral, which prevents this reagent being applied to separate iron from it, as is recommended by Berzelius for separating iron from oxide of yttria.

It differs from zirconium, in being soluble in nitric and muriatic acids, after ignition.

From cerium, in not turning of a brick red after ignition, and in the colour of its salts, which are not amethystine, but shades of green and yellow, except the nitrate, which is almost colourless.

The nitrate crystallizes in prisms, which seem to be right rhombic.

Its salts, like the corresponding ones of magnesia, are deliquescent.

The mineral from which this earth was extracted differs from talc, in the absence of any foliated structure; in not exfoliating before the blow-pipe; in giving off water in the matrass, which talc does not, being quite anhydrous, while this is a hydrated silicate. It contains twenty per cent. less silica than talc.

Leaving out of account the earth in question, the chemical constitution of this mineral comes nearest to saponite and soapstone. The specimens of saponite or soapstone analyzed by Klaproth, contain three to four per cent. more silica; four to five per cent. more magnesia; four to five more alumina, and about the same quantity of water and oxide of iron.

The specimens of saponite from Brusksveden, analyzed by Svanberg, contain eight to nine per cent. more silica; twenty-two per cent. more alumina, and ten per cent. less magnesia, and eight per cent. less water.

From the green earth often disseminated in the Italian amygdaloids it differs essentially. Most of these contain a large percentage of oxide of iron, and very little magnesia—two to six per cent. only. Several of the analyses of Serpentine and Mermolite indicate nearly the same amount of silica as in this mineral, but in them the magnesia is doubled.

Some specimens yielded a fraction of one per cent. of copper, but this is an accidental impurity, like the adhering carbonate; the acid solution of the pure mineral gives with sulphuretted hydrogen a slight milkiness only from a trace of precipitated sulphur, caused by the reduction of the small quantity of peroxide of iron present. The green colour of the mineral may probably be attributed to the presence of this peculiar earth, which produces green salts.

In consequence of the difficulty in separating the traces of magnesia, without dissolving part of the earth itself, I have not been able to ascertain the exact percentage of the earth in the mineral, nor yet determine its combining proportion.

From the quantity of chlorine evolved during the solution of the mineral and the earth in hydrochloric acid, it appears that this earth must exist in at least two degrees of oxidation: the chlorine being disengaged, just as in the case of the solution of the higher oxides of manganese* when treated with hydrochloric acid.

If the small percentage of alumina and oxide of iron present be regarded as accidental, it is probable that the constitution of the mineral is:

Two equivalents of bisilicate of magnesia and one equivalent of the peroxide of the earth, with two equivalents of water: or,

$$2\ \dot{Mg}\ \dddot{Si}^2 + NE,\ \dddot{Si} + 2\dot{H}.$$

Although most of the water is expelled by a heat below redness, still I think it must be regarded as almost all combined; since the quantity obtained is very uniform, and is within a fraction of a per cent. of two equivalents.

From the above, I conclude that the earth contained in the mineral, which is but slightly soluble in sal ammoniac, insoluble in caustic potash, and producing the above reaction with reagents, and green and yellow salts, must either be a new earth, or else a modification of some known earth not previously noticed.

The name Thalium is proposed for the base of this earth, Thalia for the earth itself, and Thalite for the mineral from which it is extracted.

In 1849, Dr. Shumard brought a soft, brittle, pale green mineral, which was collected from the cavities of an amygdaloid, three miles above Kettle River, in Minnesota, which has, when dried, much the appearance and consistence of this silicate of magnesia from Lake Superior. This Kettle River mineral, when first collected, was as soft as butter, but hardened by exposure.

I also made an analysis of this mineral, but found it to contain a much smaller quantity of magnesia, a much larger percentage of alumina, more silica, and none of this peculiar earth. The constituents are as follows:

Matter insoluble in HCl, being silicates of alumina, magnesia, and alkali, 85·2,	Composed of	Silica,	52·7
		Alumina, with a trace of oxide of iron,	20·0
		Magnesia,	4·35
		Alkali and loss,	8·15

* The mere trace of manganese present in the mineral will not account for the quantity of chlorine evolved.

Alumina, soluble in HCl,		3·3
Oxide of iron,	" "	1·2
Magnesia,	" "	0·73
Manganese,	" "	·9
Potash,		·7
Soda,		1·1
Water,		9·

This mineral does not agree exactly in composition with any mineral of which I have seen an analysis. It comes nearest in its composition to a variety of Phillipsite from Iceland, analyzed by Damour, except that magnesia replaces the lime in Phillipsite, and this mineral would therefore be a magnesian Harmotome.

It differs, too, in its degree of hardness, from the Phillipsite, or lime Harmotome.

The magnesian Harmotome from Minnesota decrepitates before the blow-pipe, and fuses to a nearly colourless blebby glass, with a faint tinge of yellow.

The analysis of this mineral gives a slight excess, which ought probably to be deducted from the alumina, which being bulky was very difficult to wash clean.

It exists in the cells of the amygdaloids of Kettle River, in its nascent state, and could be spread with a knife, just like the saponite mentioned by Alger, who states that some of the miners of Brucksveden tried to eat it as a substitute for butter.

ANALYSES OF OTHER MINERALS FROM THE NORTH SHORE OF LAKE SUPERIOR.

An analysis of a radiated mineral, of a wavy lustre and silky fibrous structure, in the cells of the amygdaloid No. 371 of Dr. Norwood's collection, from the northwest shore of Lake Superior, probably a variety of mesole, gave the following results :—

Water,	$\dot{H}$	= 12
Silica,	$\dddot{Si}$	= 43
Alumina,	$\underline{\dddot{Al}}$	= 25
Lime,	$\dot{Ca}$	= 3
Magnesia (with a trace of Mn),	$\dot{Mg}$	= 10
Oxide of iron and matter insoluble in potash,	$\underline{\dddot{Fe}}$	= 2
Alkalies,		= 4
		99

The analyses of different varieties give considerable variation in the amount of lime and magnesia, as if they replaced one another in the mineral in question.

The following is an analysis of a light-red, foliated mineral, having a pearly lustre encrusting argillaceous iron ore, collected by Dr. Norwood, on the northwest shore of Lake Superior :

Water,	$\dot{H}$	= 14·000
Insoluble silicates of alumina, lime, and alkalies, 7734,	$\dddot{Si}$	= 55·200
	$\underline{\dddot{Al}}$	= 10·400
	$\dot{Ca}$	= 5·184
	Alk	= 6·556
Oxide of iron,		a trace.
Alumina, dissolved by HCl,	$\underline{\dddot{Al}}$	= 7·040
Alkalies, with a trace of Mn,		1·600
Loss,		00·02
		100·000

The silica in this mineral agrees best with stilbite, but the water is more nearly that existing in Heulandite; the lime is nearly 2 per cent. less than in stilbite, and the alkali 4 to 6 per cent. in excess, but

that in the insoluble silicates, which were analyzed by fusion with carbonated alkali, was only estimated by deficiency, and not by actual precipitation.

An analysis of a specimen of argillaceous oxide of iron, collected by Dr. Norwood on the northwest shore of Lake Superior, resulted thus:

Water,	$\dot{H}$ = 06·00			
Silicates not taken up by hydrochloric acid,	= 63·40	$\dddot{Si}$	=	55·74
		$\underline{\dddot{Al}}$	=	02·50
		$\underline{\dddot{Fe}}$	=	02·44
		$\dot{Mg}$	=	00·73
		Alk	=	01·99
				63·40
Sesquioxide of iron,	$\underline{\dddot{Fe}}$ = 09·00			
Alumina,	$\underline{\dddot{Al}}$ = 09·30			
Magnesia,	$\dot{Mg}$ = 03·00			
Potash,	$\dot{K}$ = 07·60			
Chlorine,	a trace.			
Loss,	01·70			
	100·00			

ANALYSES OF FOSSIL BONES OF NEBRASKA.

The results of the chemical examinations of the bones of some of the fossil mammalia, from the tertiary formation of the Mauvaises Terres of Nebraska, are interesting and remarkable, as showing the change which they have undergone during the long period of interment.

PART OF LEG-BONE OF OREODON.			PART OF SCAPULA OF PALÆOTHERIUM.	
Water of absorption,	$\dot{H}$ =	2·70		2·50
Organic matter burnt off by ignition,	=	2·50		3·20
Phosphoric acid,	$\dddot{\dot{P}}$ =	36·77		32·00
Carbonic acid,	$\ddot{C}$ =	3·00		4·20
Fluorine,	F =	3·20		3·40
Lime,	$\dot{Ca}$ =	48·93	Combined with $\dddot{\dot{P}}$ =	34·00
Silica,	$\dddot{Si}$ =	3·40	$\dot{Ca}$ " " $\ddot{C}$ =	5·35
Trace of $\underline{\dddot{Fe}}$ and $\dot{Mn}$,			$\dot{Ca}$ " " F =	3·66
			$\dot{Ca}$ " " $\dddot{Si}$(?) =	0·30
			$\underline{\dddot{Fe}}$	4·50
			$\underline{\dddot{Al}}$	0·70
			$\dot{Mg}$	0·90
			$\dot{Mn}$	0·80
			$\dot{Na}$	2·04
			$\underline{\dddot{Fe}}\,\dddot{Si}$ insoluble,	1·64
			$\dddot{Si}$ dissolved by HCl,	0·30
			Loss,	0 51
		100·50		100·00

* The excess is perhaps due to the absorption of oxygen by the calcium combined with the fluorine.

It is to be regretted that time did not permit me to repeat these analyses on different varieties of specimens, and by different methods. However, I am able to furnish another analysis, of a compact portion of the tibia of Archæotherium, carefully freed from all extraneous matter, made with great care in Dr. Genth's laboratory, and under his immediate supervision, by Dr. Francis V. Greene, which has resulted very satisfactorily, and in which the fluorine was estimated by precipitation.

Water,	$\dot{\text{H}}$	= 1·97
Organic matter,		= 4·09
Phosphoric acid,	$\overset{\cdot\cdot\cdot\cdot\cdot}{\text{P}}$	= 31·19
Silicic acid,	$\dddot{\text{Si}}$	= 0·26
Carbonic acid,	$\ddot{\text{C}}$	= 2·77
Sulphuric acid,	$\dddot{\text{S}}$	= 2·19
Fluorine,	F	= 2·46
Chlorine,	Cl	= 0·02
Lime,	$\dot{\text{Ca}}$	= 50·83
Magnesia (with a trace of $\dot{\text{Mn}}$),	$\dot{\text{Mg}}$	= 1·14
Baryta,	$\dot{\text{Ba}}$	= 1·10
Potash,	$\dot{\text{K}}$	= 0·28
Soda,	$\dot{\text{Na}}$	= 1·57
Iron and alumina,		a trace.
		99·87

These analyses are remarkable: first, in showing the existence of a notable quantity of fluorine, amounting to from 2 to 3 per cent., sufficient to etch glass very distinctly, when the bones are treated with strong sulphuric acid, and gently heated: second, in proving the existence of from 2 to 4 per cent. of the original organic matter, and from 31 to 37 per cent. of the phosphate of lime in the bones of animals, which have been entombed in these early tertiary deposits ever since the Alps first began to lift their heads out of the ocean, and in which they have been enclosed, the almost inconceivable length of time that has elapsed during a vast geological epoch, in which that great mountain chain of Europe has been gradually thrusting its peaks to ten or twelve thousand feet above the ocean; and while the Andes of South America, during the same period, have attained probably even a greater elevation.

Reflecting on the origin of the fluorine discovered in these Nebraska fossil bones, it becomes a question whether it is an original constituent of the bones of the living animal, or has been introduced into their composition after death. Since the analysis of the bones of existing animals indicates but a mere trace of fluorine, it seems more probable that that element has been introduced as fluoride of calcium by infiltration during the gradual process of fossilization, after the manner of pseudomorphism in minerals, the fluoride of calcium gradually replacing the organic matter, as transformation proceeded, than that it should have been an original constituent of the bones of the living animal. Still, the subjoined analyses of the enclosing matrix gives no evidence whatever of the existence of fluorine in these deposits now.

If the fluorine has really been derived from these deposits, we are forced to the conclusion that it has all been removed by the process of pseudomorphism. May we not, however, rather look to the saline waters, now common in that country, as the source of the fluorine; or, perhaps, to the waters of the lake, bay, or estuary, in which the bones may have lain macerating, previous to their long interment?

It is worthy also of note that Dr. Greene's analysis shows the presence of sulphate of baryta in the compact portion of the bone he analyzed; and Dr. Genth discovered minute crystals of sulphate of baryta in the cavities of some of the bones by the aid of a strong magnifier.

		Analysis of Matrix of Skull of Oreodon.	Analysis of Matrix of Scapula of Palæotherium.	
Water of absorption,	$\dot{H}$	= 2·50		4·00
Flesh-coloured, siliceous earth, insoluble in HCl.		= 33·00	Silica,	59·00
Lime,	$\dot{Ca}$	= 30·90		10·00
Carbonic acid,	$\ddot{C}$	= 19·00		12·20
Sesquioxide of iron,	$\underline{\dddot{Fe}}$	= 2·00		7·20
Alumina,	$\underline{\dddot{Al}}$	= 1·00		4·20
Manganese,	$\dot{Mn}$	= 1·00		
Magnesia,	$\dot{Mg}$	= 1·00		
Phosphoric acid,		= 1·80		1·90
Chlorine,	Cl	= 0·44		0·037
Potash,	$\dot{K}$	= 4·08	Sulphuric acid,	0·03
Loss and soda,	$\dot{Na}$	= 3·28	Loss and alkalies,	1·433
		100·00		100·000

ARTICLE V.

SYSTEMATIC CATALOGUE OF PLANTS OF WISCONSIN AND MINNESOTA, BY C. C. PARRY, M.D., MADE IN CONNEXION WITH THE GEOLOGICAL SURVEY OF THE NORTHWEST, DURING THE SEASON OF 1848.

The accompanying list of plants embodies the observations I have been able to make during the past season, in connexion with the Geological Survey of the Northwest, under the direction of Dr. Owen.

I have also incorporated some personal observations made during a previous season in the State of Iowa; being properly comprised within the District of the Northwest; and enabling me to present a more complete view of the botanical features of this region, than could otherwise be done during a single season's operations.

The precise region of country covered by these observations, will be sufficiently indicated by the subjoined localities. The time of collection, with other points of special interest, also accompany each separate name, in the order in which they stand.

The order followed is the *Natural System;* and the authority used, "*Torrey and Gray's North American Flora,*" and "*Gray's Botany of the Northern United States.*"

Being desired by Dr. Owen's instructions to have special reference to the geological relations of the plants observed, a few preliminary suggestions on this point will not be deemed out of place.

It is evident on the slightest observation, that all the relations of accompanying vegetation to geology are to be sought through the common medium of the *soil:* in so far only as any geological formation is capable of giving a distinctive character to this medium, may we expect to find geological characters equally marked on the vegetation. This fact has been particularly noticeable in the region of country traversed during the past season. The passage from one geological formation to another—especially when distinctly marked—is always accompanied with a change in the botanical features, perhaps proportioned to the extent of exposure, but still more obviously connected with evident difference in the overlying soil, dependent on this geological change.

Another example is found in the modifying influence of trap ranges upon the superincumbent vegetation, which influence is at times so marked, that even when not exposed, the direction and width of the range can be traced with considerable certainty by their means alone.

The drift deposits, which, in their varying character in different parts, give such a striking feature to northwestern scenery, are always clothed with a characteristic vegetation. Thus, on the gravelly ridges of the Upper St. Peter's, which in their main development go to form that singular character of scenery known as the "*Coteau des Prairies*," dividing the tributaries of the Upper Mississippi from those of the Missouri, we invariably meet with many or all of the following grouped plants, viz., *Castilleja Sessiliflora, Psoralea esculenta, Œnothera serrulata, Oxytropis Lamberti, Lygodesmia juncea, Bouteloua oligostachya*, and others less fixed.

To the eastward, the corresponding water-shed between Lake Superior and the Mississippi, furnishes a growth of *Pinus Banksiana*, with an associated undergrowth of *Vaccinium tenellum, Gaultheria procumbens, Lycopodium*, etc. The two deposits thus furnishing as marked a contrast in their vegetation, as in their geographical position or geological features.

These points, with others that may be illustrated from the accompanying list, show that there is a very observable relationship between the Flora of a country and its geology.

But it is farther to be observed that botany, from its peculiar intermediate position, connected and dependent, alike for all its varied features, both on the atmosphere and soil, is called to maintain corresponding relations to each; being at the same time subject to the modifying influence of atmospheric conditions and variations of soil. Thus called to supply such varying indications, it must necessarily be less intimate in its connexion with any one; variety in this, as in every case, must be at the expense of definiteness.

An interesting illustration of this fact is to be noticed on the shores of Lake Superior, where we meet with a singular blending of *Littoral* and *Alpine* plants: thus we find *Lathyrus maritimus* (*Beach-pea*), and *Hudsonia ericoides*, common to the Atlantic sea-beach, and intimately connected with a similarity of soil; and side by side with these, *Potentilla tridentata* and *Clastonia rangiferina*, peculiar to Alpine and Arctic regions, in connexion with a similarity of climate. Such instances might be multiplied, all showing that the true province of botany, as a branch of physical geography, is with its own proper knowledge, to combine that varied information, that cannot be otherwise gleaned from any one department of Natural History.

It is this view, no doubt, that gives to the botany of a new country its chief interest, and makes a *suite* of native plants valuable *portable indices* of the country they inhabit, of its agricultural capacities, climate, and external features, affording a ready means of comparison or contrast with other countries. May they not, when enlarged experience has traced with more accuracy these relations, and especially when we keep in view the principle so much insisted on in geology, viz., to depend more on the *grouping* of specimens, and drawing nice distinctions, than in isolated examples,—may they not take the same rank to agriculture that fossils do to geology?

This principle always has been in general application. By it the farmer naturally judges of the fertility or barrenness of unploughed fields, while to an experienced botanist, a complete suite of the plants of any country would convey a greater amount of interesting general information, and impart more definite notions of a country, than can be drawn from any single source.

The Indian uses, economical and medicinal, of the plants observed, are made a special item in my instructions, and on this point some interesting and unexpected facts have been noted. This is particularly true of the native articles of diet, nearly all of which I have been enabled to refer to their scientific place, in connexion with the Indian name in most common use, and a brief enumeration of their uses.

There is one fact in this connexion that has struck me as a matter of much interest, and I briefly advert to it here. Of the native vegetable productions of this region, several of the most useful in an economic or commercial point of view are connected with those features of country which seem least desirable. Thus the excellent *cranberry* occupies its irreclaimable marshes; the delicious *huckleberry* its barren ridges; while the staple *wild rice* edges its innumerable lakes. The suggestion might be carried further, but these will be sufficient to draw forth an obvious inference.

With regard to the medicinal articles used, my information is less important, due not so much to the nature of the subject as the difficulty of obtaining accurate information. Medicine, in the mind of the Indian, is always connected with superstitious observances, and is inseparably blended with his religious notions. The efficacy of the simplest remedies are attributed to some supernatural agency, and, as a consequence, more credit is given to the manner of administering, or unmeaning ceremonies connected with

it, than to the thing itself. With all this, an air of mystery is thrown over the subject, combining to render reliable information, on the one hand, difficult to obtain, and on the other, good for nothing when obtained. The subject in fact belongs more properly to the *moral* than the *natural* philosopher, and I have contented myself with a single specification of alleged virtues, without taking the trouble to classify them.

Particular attention has been given to the class of ferns, from their more intimate relation with geology, of which, including the allied orders, *Equisetaceæ* and *Lycopodiaceæ*, thirty-eight different species have been observed, including some of much interest.

The class of *forest trees* having been designed for a special report, they are merely included in my list in their proper natural order, without reference to their comparative geographical distribution or relative economical value.

The number of plants comprised in this list is seven hundred and twenty-seven, included in one hundred and six natural orders; many of these have never before been referrrd to this region.

I am indebted to the distinguished botanist, Dr. John Torrey,—and what American botanist is not?—for the authentication of my doubtful specimens, particularly in the class of *grasses* and *sedges*.

My acknowledgments are also due to Mr. William S. Sullivan, of Ohio, for labelling my entire collection of *mosses*.

To Dr. S. B. Mead, of Illinois, I also owe thanks for interesting information, and obliging assistance, in making out this report.

For Indian names, I have relied mainly on information derived from the hospitable Missionaries, Rev. R. Hopkins, of Traverse des Sioux, and Mr. Ely, of La Pointe, Lake Superior.

EXOGENS.

Ranunculaceæ.—Atragene Americana, (Sims.) May 18th. Shady rocks at the head of Lake St. Croix. Clematis Viorna, (L.) June 9th. Banks of the Mississippi, near Davenport, Iowa. Clematis Virginiana, (L.) Copses. July. Pulsatilla patens, (Mill.) May 15th. In fruit. Galena, Ill. This characteristic and handsome plant occurs abundantly to the north and west of the locality specified, preferring high prairies and gravelly ridges, which, in early spring, it adorns with its elegant blue flowers, or later, with its no less beautiful plumed fruit. It possesses the acrid properties, and probably equal medicinal qualities, with a closely allied European species. It is said by the Indians frequently to occasion sores on the lips of children, attracted by their showy blossoms. It may farther be mentioned as an interesting fact in connexion with its geographical range, that the same plant is found in New Mexico, specimens from that locality having been shown me by Dr. Englemann, of St. Louis. Anemone Caroliniana, (Walt.) May 3d. Mississippi River bank, Davenport, and Rock Island. The geographical range of this interesting species is deserving of notice. First known as a native of the Carolinas, it is again met with in Louisiana, Texas, and Arkansas, thence finding its way to the Missouri and Platte Rivers; the locality, just specified, probably determining its northeastern limits. It here grows always associated with Draba Caroliniana, and Androsace occidentalis; a significant relationship, connecting as it were the two extremes, Carolina and Nebraska. Anemone nemorosa, (L.) May. Woods. Anemone cylindrica, (Gray.) June. A characteristic plant of dry rolling prairies, throughout the Northwest. Anemone Virginiana, (L.) July. Woods of Iowa. Anemone Pennsylvanica, (L.) June. River banks. Hepatica triloba, (Chaix.) April. Woods and hills. Thalictrum anemonoides, (Michx.) April. Common. Thalictrum dioicum, (L.) May. Copses, Lake St. Croix. Thalictrum Cornuti, (L.) June. River banks. Ranunculus aquatilis, (L.) July. Still brooks and ponds. Ranunculus Purshii, (Richards.) June. Stagnant brooks. Ranunculus reptans, (L.) August. Sandy shores of lakes, St. Croix. Ranunculus cymbalaria, (Pursh.) July 5th. Little Rock, Upper St. Peter's. This species is generally associated with salines, but this locality seemed to be an exception. Ranunculus abortivus. (L.) May. Woods and copses. Ranunculus Pennsylvanicus, (L.) August. St. Croix river banks. Ranun-

culus fascicularis, (Muhl.) April. Dry river banks. Ranunculus repens, (L.) May. Wet places, common. Caltha palustris, (L.) May. Swamps. Coptis trifolia, (Salisb.) Bogs. St. Croix. Isopyrum biternatum, (Torr and Gr.) Shady woods, Blue Earth River. Aquilegia Canadensis, (L.) June. Rocks. Delphinium azureum, (Michx.) June. A characteristic Larkspur, growing on sandy ridges or high prairies, Iowa and Illinois. Actæa rubra, (Willd.) May. Woods and Copses, Iowa. Actæa alba, (Bigel.) With the preceding.

ANONACEÆ.—Asimina triloba, (Duval.) April. "Papaw." Head of Des Moines Rapids, Mississippi River.

MENISPERMACEÆ.—Menispermum Canadense, (L.) May. A common vine. The root is a popular tonic.

BERBERIDACEÆ.—Leontice thalictroides, (L.) April. Woods. Podophyllum peltatum, (L.) May. Rich woods, the fruit eatable; the root cathartic.

CABOMBACEÆ.—Brasenia peltata, (Pursh.) July. "Water shield." Floating on shallow lakes, St. Croix.

NYMPHÆACEÆ.—Nymphæa odorata, (Ait.) July. Water lily. Nuphar advena, (Ait.) July. Yellow water lily.

SARRACENIACEÆ.—Sarracenia purpurea, (L.) June. Pitcher plant. Bogs of the St. Croix.

PAPAVERACEÆ.—Sanguinaria Canadensis, (Linn.) April. The medicinal blood root.

FUMARIACEÆ.—Dicentra Cucullaria, (D. C.) April. Rich woods. Corydalis aurea, (Willd.) May. River banks. A very variable plant, according to the character of the soil in which it grows. Corydalis glauca, (Pursh.) August. Trap rocks, at Falls of St. Croix.

CRUCIFERÆ.—Nasturtium sinuatum, (Nutt.) July 14th. River bank, Lower St. Peter's. Found also in similar situations in Oregon. Nasturtium palustre, (D. C.) July. River banks. Nasturtium natans, (D. C.) July. A singular aquatic species, more common in the West than at the East. Cardamine rhomboidea, (D. C.) May. Wet places in prairies, Iowa. Cardamine hirsuta, (L.) May. Moist margins of brooks. Dentaria laciniata, (Muhl.) April. Rich woods. Arabis lyrata, (L.) May. Rocks. Galena, Ill. Arabis dentata, (Torr. and Gr.) June. River banks. Arabis hirsuta, (Scop.) May. Rocky places, head of Lake St. Croix. Arabis lævigata, (D. C.) May. Rocky river-banks. Arabis Canadensis, (L.) June. St. Peter's and St. Croix. Erysimum cheiranthoides, (L.) July. River banks. Sisymbrium canescens, (Nutt.) May. Pastures and river-banks, Davenport, Iowa. Draba Caroliniana, (Walt.) April. Dry and exposed banks of the Mississippi, Davenport, and Rock Island. Lepidium Virginicum, (L.) Waste places. Capsella bursa-pastoris, (Mœnch.) Fields and streets.

CAPPARIDACEÆ.—Polanisia graveolens, (Raf.) July. Gravelly banks of the Upper Mississippi.

VIOLACEÆ.—Viola cucullata, (Ait.) April. Low grounds. Viola pedata, (L.) May. A showy species, adorning the rolling prairies of Iowa with its early blue blossoms. Viola delphinifolia, (Nutt.) May. Davenport and Upper Mississippi. Closely resembling the former, but readily distinguished on a close examination. Viola Canadensis, (L.) June. St. Peter's. Viola Muhlenbergii, (Torr.) May. Lake St. Croix.

CISTACEÆ.—Helianthemum Canadense, (Michx.) June. Dry hills and prairies. Iowa and Minnesota. Hudsonia ericoides, (L.) Common to the shores of Lake Superior, the barren ridges of the St. Croix, and the Atlantic sea-beach. Lechea minor, (Lam.) July. "Pin-wee." St. Croix.

DROSERACEÆ.—Drosera rotundifolia, (L.) July. "Sun-dew." Moist sand on the margins of lakes. Minnesota. Parnassia Caroliniana, (Michx.) August. Wet places on prairies. St. Peter's and St. Croix.

HYPERICACEÆ.—Hypericum pyramidatum, (Ait.) July. River banks Upper Mississippi and St. Peter's. Hypericum Canadense, (L.) August. St. Croix River. Elodea Virginica, (Nutt.) July. Swamps in the Northwest.

CARYOPHYLLACEÆ.—Silene stellata, (Ait.) July. Woods and river banks. Silene nivea, (D. C.) July. Ravines. Davenport, Iowa. Silene antirrhina, (L.) June. Dry soil and exposed rocks. Iowa and Minnesota. Arenaria stricta, (Michx.) July. Rooting on detached rocks, head of Lake St. Croix. Mœhringia lateriflora, (Feuzl.) May. Wet places, St. Croix. Stellaria longifolia, (Muhl.) May. Moist, grassy places, Upper Mississippi. Cerastium nutans, (Raf.) May. Moist, sandy places, Upper Mississippi. Mollugo verticillata, (L.) August. Exposed rocks and sandy fields, St. Croix.

PORTULACACEÆ.—Portulaca oleracea, (L.) Crevices of rocks on the Upper St. Peter's. Talinum

parviflorum, (Nutt.) July 1st. Crevices of the exposed granite and quartzite rocks, Upper St. Peter's, associated with Lycopodium rupestre and Woodsia Ilvensis; differing from the more common T. teretifolium, in the characters specified by Nuttall, but still doubtful as a distinct species. Claytonia Virginica, (L.) April. Rich hillsides.

Malvaceæ.—Abutilon Avicennæ, (Gaertn.) July. Yards and roadsides, abundantly naturalized about western towns.

Linaceæ.—Linum rigidum, (Pursh.) July. "Yellow flax." High prairies of Iowa.

Geraniaceæ.—Geranium maculatum, (L.) May. Copses and fields. Geranium Carolinianum, (L.) May. Waste places, Iowa. Geranium Robertianum, (L.) August. Shady crevices of trap-rocks, Falls of St. Croix.

Oxalidaceæ.—Oxalis Acetosella, (L.) "Wood-sorrel." Rooting in moss, in deep woods, Lake Superior. Oxalis violaceæ, (L.) May. Dry banks, Iowa. Oxalis stricta, (L.) Waste places.

Balsaminaceæ.—Impatiens pallida, (Nutt.) August. Springy places, St. Croix. Impatiens fulva, (Nutt.) With the preceding.

Zanthoxylaceæ.—Zanthoxylum Americanum, (Mill.) April. "Prickly ash." Forming troublesome thickets on river-banks throughout the Northwest. Ptelia trifoliata, (L.) June. Dry river-banks. Called "water-ash," from the singular appearance of its fruit.

Anacardiaceæ.—Rhus typhina, (L.) June. St. Croix. Rhus glabra, (L.) The most common species of *sumac*. The milky juice from the fresh-cut branches affords an indelible ink. Rhus Toxicodendron, (L.) "Poison-ivy." Very abundant on all river-banks, thickets, &c. Rhus venenata, (D. C.) "Poison-ash." Deep, swampy woods, St. Croix. Rhus aromatica, (Ait.) June. Sandy shore of Red Cedar River, Iowa.

Aceraceæ.—Acer spicatum, (Lam.) Upper St. Croix and Lake Superior. Acer saccharinum, (L.) Interior of Iowa, Upper St. Croix, &c. Acer dasycarpum, (Ehr.) Alluvial river-bottoms throughout the Northwest. Acer rubrum, (L.) Falls of St. Croix. Negundo aceroides, (Mœnch.) River-bottoms, Iowa.

Celastraceæ.—Staphylea trifolia, (L.) May. Thickets, Iowa. Celastrus scandens, (L.) This common vine abundantly found in thickets, and along banks of streams, throughout the Northern States, popularly known by the name of "Staff-tree," or "Climbing Bitter-sweet," is frequently resorted to by the Indians of the Northwest, in times of scarcity, as an article of food. The vine itself, cut into pieces of a convenient size, is boiled till the thick bark acquires a pulpy consistence, and the water becomes impregnated with mucilage. The woody part being rejected, the rest is eaten. By the Chippewa Indians it is called Bi-ma-quat. Euonymus atropurpureus, (Jacq.) June. Blue Earth River, and banks of the Mississippi. Showy in the frequent abundance of its scarlet fruit in winter. The root has also attained note in some quarters as a medicinal agent.

Rhamnaceæ.—Rhamnus alnifolius, (L'Hen.) May. Alder swamps of the St. Croix River. Rhamnus longifolius, (Pursh.) Banks of the Mississippi, near Davenport, Iowa. Ceanothus Americanus, (L.) July. "Red root." A shrubby plant, well known on the Iowa prairies as a troublesome obstacle, by its tough roots in first breaking the soil. Ceanothus ovalis, (Bigelow.) May. Interior counties of Iowa, and on dry sandy ridges of the St. Croix; in the latter locality seeming to take the place of the preceding species, and an indication of a more barren soil.

Vitaceæ.—Vitis riparia, (Michx.) "River-side Frost-grape:" the only northwestern species. Ampelopsis quinquefolia, (Michx.) June. River-banks.

Polygalaceæ.—Polygala purpurea, (Nutt.) July. Wet and rather barren places, Iowa and Minnesota. Polygala incarnata, (L.) Dry soil, interior of Iowa. Polygala cruciata, (L.) July 28th. Moist margins of swampy lakes, St. Croix. Polygala verticillata, (L.) Dry hills, Iowa. Polygala senega, (L.) "Seneca snake-root." Polygala polygama, (Walt.) July. Sandy soil, St. Croix. Polygala paucifolia, (Willd.) Long Portage Trail from Lake Superior to the Upper St. Croix.

Leguminosæ.—Lathyrus maritimus, (Bigelow.) "Beach-pea." Common to the sandy shore of Lake Superior, and the Atlantic sea-beach. Lathyrus venosus, (L.) June. Copses. St. Peter's. Lathyrus ochroleucus, (Hook.) May. St. Croix and St. Peter's. Lathyrus palustris, (L.) Moist river-banks, St. Peter's. Phaseolus diversifolius, (Pers.) August. "Wild bean." Gravelly banks of the Mississippi, Davenport, Iowa. Apios tuberosa, (Mœnch.) August. The root of this common plant, abundantly scattered on the banks of streams, and alluvial bottoms throughout the United States, is the

true "Pomme de Terre" of the French voyageurs, and the "Mdo," or wild potato of the Sioux Indians. By the latter name it is extensively used as an article of diet. It grows in great abundance, and of superior quality, on the banks of the St. Peter's. When properly cooked, it is by no means unpalatable. Amphicarpæa monoica, (Nutt.) August. Rich woods, bearing underground pods, like the peanut of commerce. Desmodium nudiflorum, (D. C.) August. Woods, St. Croix. Desmodium acuminatum, (D. C.) August. St. Croix. Desmodium Canadense, (D. C.) July. Moist banks of streams. Lespideza capitata, (Michx.) August. Dry prairies, Iowa and Minnesota. Astragalus caryocarpus, (Ker.) May. Gravelly ridges in the interior of Iowa, Fort Snelling, at the junction of the Mississippi and St. Peter's Rivers, and abundant on the latter stream, being a characteristic plant of the peculiar drift deposit of that region. The fruit, which is a pod, closely resembles a plum in external appearance, from which fact it has received the common name of "ground-plum." The thick fleshy exterior is highly charged with moisture, having the usual taste of the pea tribe, and is frequently used to allay the thirst of the traveller on the great western plains. Astragalus Canadensis, (L.) July. Banks of the Mississippi and St. Peter's Rivers. Oxytropis Lamberti, (Pursh.) June. Upper St. Peter's, on drift ridges. Glycyrrhiza lepidota, (Nutt.) June. "Wild liquorice." Banks of the Blue Earth, St. Peter's, and St. Croix Rivers. Possessing some of the sensible qualities of the commercial liquorice, without its sweetness. Tephrosia Virginiana, (Pers.) July. Sandy soil, Davenport, Iowa. Amorpha fructicosa, (L.) May. A handsome shrub, edging river-banks throughout the Northwest. Amorpha nana, (Nutt.) June 18th. High prairies on Blue Earth River. A characteristic plant of woodless, grassy hills on the Missouri, often diffused, as Mr. Nuttall remarks, "like heath in Europe, over many acres in succession, and is the only upland shrub apparently capable of withstanding the peculiarities of this climate." (Nutt., Genera, vol. ii. p. 91.) Amorpha canescens, (Nutt.) July. This is the noted "lead-plant" of Iowa and Wisconsin. Its value as a mineral indication may probably be summed up in this. It attaches itself with most luxuriance to rocky crevices and spots about which the peculiar dry earth, indicating a mineral vein, exists, and the miner is thus guided in making his excavations. Farther than this any definite relation with the lead-bearing rock is sufficiently disproved by the extensive geographical range of this plant, from British America to Texas. Psoralea argophylla, (Pursh.) July. High prairies in Iowa and Minnesota. A characteristic plant, with silvery foliage. Psoralea esculenta, (Pursh.) June 3d. Gravelly ridges of the St. Peter's. This is the valuable plant known as the "Indian turnip,"—"Pomme de Prairie," of the French voyageurs; "Tipsinah" of the Sioux Indians. It occurs over a wide range of country between the Mississippi and the Rocky Mountains, and is a characteristic plant of the "Coteau des Prairies." The root, frequently attaining the size of a hen's egg, is of a regular, cylindric, ovoid shape, consisting of a thick leathery envelope, easily separating when fresh from its smooth internal part. The latter is of friable texture, except towards the axis, where some ligneous fibres are intermixed. When dry, it acquires a sweetish taste, and is easily pulverized, affording a light, starchy flour, suitable for all the uses of the ordinary article. When growing its aspect is that of a Lupine. It selects a dry, gravelly, but not barren soil, and is well worthy the attention of cultivators, as an interesting production of the Northwest. Petalostemon violaceum, (Michx.) June. Dry hills throughout the Northwest. Petalostemon candidum, (Michx.) August. Dry prairies. Petalostemon villosum, (Nutt.) Sandy banks. "Traverse des Sioux," Falls of St. Anthony, Barrens of St. Croix. A very elegant species in flower and foliage. Trifolium reflexum, (L.) June. Buffalo clover. Low grounds. Iowa. Trifolium repens, (L.) St. Peter's and St. Croix. Lupinus perennis, (L.) St. Croix Barrens. Baptisia leucantha, (Torr. & Gr.) July. Rich soil, Davenport and St. Croix. Baptisia leucophœa, (Nutt.) May. Dry prairies. Iowa. Cercis Canadensis, (L.) April. "Red-bud." Banks of the Mississippi. Davenport and Rock Island. Cassia chamæcrista, (L.) July. Sensitive pea. Sandy soil. Iowa.

Rosaceæ.—Prunus Americana, (Marsh.) Wild plum. Forming thickets. Mississippi and St. Croix. Generally producing an abundance of fruit. Cerassus pumila, (Michx.) Sand-cherry. Sandy banks of Lake St. Croix. Beach of Lake Superior. Cerassus Pennsylvanica, (Loisel.) Bird cherry. St. Croix. Cerassus Virginiana, (D. C.) Choke cherry. St. Croix. Spiræa opulifolia, (L.) June. Rocky river banks, Iowa. Spiræa salicifolia, (L.) July. Wet places. St. Peter's and St. Croix. Spiræa tomentosa, (L.) July. Margins of lakes. Minnesota. Agrimonia Eupatoria, (L.) August. Waste places. St. Croix. Geum Virginianum, (L.) June. Shady hills. St. Peter's. Geum strictum, (Ait.) Moist places. St. Peter's. Geum triflorum, (Pursh.) May. Head of Lake St. Croix, Fort Snelling, and St. Peter's. This fine species, particularly beautiful in its plumed fruit, is well worthy to usurp the place of

the Geum urbannum, of our gardens. In its geographical range it is pretty constantly associated with Pulsatilla patens, but is less common. Waldsteinia fragarioides, (Tratt.) Dividing ridge between the St. Croix and Bois Brulé Rivers. Potentilla Norvegica, (L.) July. Waste places. St. Croix. Potentilla paradoxa, (Nutt.) July. Sandy margins of Cornelian Lake, near St. Croix River. Potentilla Pennsylvanica, (L.) July 4th. Granite knolls near "Little Rock," Upper St. Peter's. Potentilla arguta, (Pursh.) June. A very common plant on the dry rolling prairies of Iowa and Minnesota. Potentilla anserina, (L.) July. Mississippi, above Fort Snelling. Potentilla tridentata, (Ait.) Shore of Lake Superior. Comarum palustre, (L.) July. Cranberry bogs, St. Croix. Fragaria Virginiana, (Ehrh.) Common strawberry. Fields and prairies, Iowa and Minnesota. Fragaria vesca, (L.) Wood strawberry. St. Croix. Rubus odoratus, (L.) Flowering Raspberry. South shore of Lake Superior. Rubus triflorus, (Richards.) May. Shady places. St. Croix. Rubus strigosus, (Michx.) Red raspberry. Falls of St. Croix. Not abundant, except in the vicinity of settlements. Rubus occidentalis, (L.) Black raspberry. St. Croix. Rubus villosus, (Ait.) High blackberry. Forming thickets. Falls of St. Croix. Rosa lucida, (Ehrh.) May. Dry soil. Iowa. Rosa blanda, (Ait.) May. Prairie rose. Iowa and Minnesota. Cratægus tomentosa, (L.) June. A fine shrub, distinguished for the profusion of its flowers and the beauty of its foliage. Banks of the Mississippi. Cratægus coccinea, (L.) Variety mollis. May. Davenport, Iowa. Cratægus Crus-galli, (L.) June. Rock Island, Ill. Pyrus coronaria, (L.) April. Crab-apple. Abundant on the banks of the Mississippi, near Davenport, Iowa, extending north to the St. Peter's. Pyrus arbutifolia, (L.) Choke-berry. Bogs. St. Croix. Pyrus Americana, (D. C.) Mountain ash. Shores of Lake Superior. Amelanchier Canadensis, (Torr. and Gr.) April. This widely-spread and variable shrub seems to require a high northern latitude to perfect its fruit. In such situations it becomes an important article of diet, and forms a frequent ingredient in the Pemican, or pounded meat, so extensively used in those regions. The shrub is there known by the name of Pembina, which name has been applied to the Red River settlement of Lord Selkirk.

Lythraceæ.—Ammannia latifolia, (L.) August. Banks of Mississippi, near Des Moines Rapids. Lythrum alatum, (Pursh.) July. Margins of ponds. Iowa and Minnesota. Decodon verticillatum, (Ell.) Fish Trap Rapids, Upper St. Croix.

Onagraceæ.—Epilobium angustifolium, (L.) July. Waste places, St. Croix. Epilobium coloratum, (Muhl.) July. Moist places. St. Croix. Epilobium palustre, (L.) July. Bogs. St. Croix. Œnothera biennis, (L.) Thickets, throughout the Northwest. Œnothera rhombipetala, (Nutt.) July 21st. Sandy cliffs about Cornelian Lake. This species has only been found hitherto on the Arkansas and Missouri. Œnothera serrulata, (Nutt.) June. A characteristic plant of the gravelly ridges on the St. Peter's, and in the interior of Iowa. Gaura biennis, (L.) August. Dry fields. Davenport, Iowa. Ludwigia palustris, (Ell.) Wet places. St. Croix.

Circæaceæ.—Circæa lutetiana, (L.) Moist woods. St. Croix. Circæa alpina, (L.) Deep woods. Upper St. Croix.

Halorageæ.—Myriophyllum verticillatum, (L.) Floating in still ponds. Interior of Iowa. Hispuris vulgaris, (L.) July. Reedy swamps on the St. Peter's, near Traverse des Sioux.

Cactaceæ.—Opuntia vulgaris, (Mill.) July. Crevices of the bare granite rocks, Upper St. Peter's, and at the Falls of the St. Croix. This species seems to be nearer to our common Prickly Pear than to the O. Missouriensis, which latter is referred to the Rocky Mountains, and the plains of the Missouri.

Grossulaceæ.—Ribes cynosbati, (L.) Prickly gooseberry. Rocky woods. Ribes Missouriense, (Nutt.) Borders of streams. Iowa. As far north as the St. Peter's River. This characteristic species is to be noted for the luxuriance of its growth, and frequent abundance of its wild fruit. It is farther worthy of note, for affecting a dryer soil than is common to this class of plants; thus it would seem peculiarly fitting it for cultivation in the region of which it is a native. Ribes floridum, (L.) May. Wild Black Currant. Abundant on the alluvial bottoms of the Upper Mississippi. Ribes rubrum, (L.) Common Red Currant. Head of the Chippewa River. Mr. A. Randall. This common fruit-bearing shrub of our gardens was frequently observed growing wild by various members of the Geological corps, during the season of 1847, when they had the opportunity of ascertaining its identity in fruit, with the red currant of our gardens.

Cucurbitaceæ.—Echinocystis lobata, (Torr. and Gray.) Alluvial river banks. St. Croix and St. Peter's.

Crasulaceæ.—Penthorum sedoides, (L.) July. Wet places. St. Croix.

SAXIFRAGACEÆ.—Saxifraga Pennsylvanica, (L.) May. Bogs. St. Croix. Heuchera Richardsonii, (R. Br.) June. A common plant, characteristic of dry rolling prairies. Iowa and Minnesota. Mitella diphylla, (L.) May. Shady hillsides. St. Croix. Mitella nuda, (L.) Deep woods. Upper St. Croix. Chrysosplenium Americanum, (Schwein.) Northern brooks. Upper St. Croix.

UMBELLIFERÆ.—Hydrocotyle Americana, (L.) August. Springy places. Falls of St. Croix. Sanicula Canadensis, (L.) June. Blue Earth River. Sanicula Marilandica, (L.) June. Blue Earth River. Eryngium aquaticum, (L.) Rattlesnake root. Moist prairies. Iowa and Illinois. Polytænia Nuttalli, (D. C.) June. Prairies near Davenport, Iowa. Heracleum lanatum, (Michx.) Moist banks of the St. Peter's River. Archemora rigida, (D. C.) August. Banks of streams. Iowa. Archangelica atropurpurea, (Hoffm.) Alder swamps on St. Croix River. Thaspium barbinode, (Nutt.) June. Woods. Blue Earth River. Thaspium auerum, (Nutt.) May. High prairies. St. Croix and St. Peter's. Zizia aurea. (Koch.) Moist places on prairies. St. Peter's. Zizia integerrima, (D. C.) June. Dry banks of rivers. Iowa. Cicuta maculata, (L.) June. Poison hemlock. Covering acres in succession in rich moist prairies, in the interior of Iowa. Cicuta bulbifera, (L.) August. Margins of lakes. St. Croix. Sium latifolium, (L.) River margins. St. Croix. Cryptotænia Canadensis, (D. C.) Rich woods throughout the Northwest. Chærophyllum procumbens, (Law.) May. Rock Island, Illinois. Osmorrhiza longistylis, (D. C.) May. Sweet Cicely. Woods. St. Peter's and St. Croix. Osmorrhiza brevistylis, (D. C.) St. Croix.

ARALIACEÆ.—Aralia racemosa, (L.) Spikenard. Rich woods in the Northwest. Aralia nudicaulis, (L.) Wild Sarsaparilla. Shady hillsides, throughout the Northwest. Aralia hispida, (Michx.) August. Trap rocks. Falls of St. Croix. Panax quinquefolium, (L.) Ginseng. Rock Island, Ill.

CORNACEÆ.—Cornus alternifolia, (L.) Dogwood. St. Peter's and St. Croix. Cornus circinata, (L'Hen.) June. Banks of the St. Peter's. Cornus sericea, (L.) June. Moist banks of streams. Upper Mississippi, St. Peter's, &c. This is the only shrub extensively known and prized as the genuine "Kinnikinnic," or smoking ingredient, in such general use among all the Indian tribes of the Northwest. In those sections of country where this species is not found, other barks or leaves are resorted to as substitutes; but wherever this species is found, it takes preference over all others. The dried inner bark is the part used, being mixed for smoking with equal parts of tobacco, to which it is said to impart an agreeable pungency. Cornus stolonifera, (Michx.) May. Wet rocky banks of streams. St. Croix and Lake Superior. This is the most common substitute for the genuine Kinnikinnic by the Indians about Lake Superior. Its common name of Red Osier or Willow, has introduced considerable confusion into the popular synonymy. I am not informed of any species of Salix (or Willow proper), being used for Kinnikinnic. Cornus paniculata, (L'Hen.) July. Thickets on Blue Earth River. Cornus asperifolia, (Michx.) July. Blue Earth River. Cornus Canadensis, (L.) Pine woods. St. Croix.

CAPRIFOLIACEÆ.—Linnæa borealis, (Gronov.) Deep pine woods and cedar swamps. Upper St. Croix and Lake Superior. Symphoricarpus racemosus, (Michx.) June. Snow-berry. A very common shrub on the St. Peter's. Lonicera parviflora, (Lam.) May. Wild Honeysuckle. St. Croix. Lonicera ciliata, (Muhl.) Twin Honeysuckle. Upper St. Croix. Diervilla trifida, (Mœnch.) June. Hillsides. St. Croix. This plant is in use among the Indians as a diuretic. Triosteum perfoliatum, (L.) June. Copses and river banks. Iowa and Minnesota. Sambucus Canadensis, (L.) Common elder. Abundant on the Lower St. Peter's. Sambucus pubens, (Michx.) May. Stillwater, Minnesota. Viburnum Lentago, (L.) June. Banks of the St. Peter's. Viburnum dentatum, (L.) Arrow wood. St. Peter's. Viburnum pubescens, (Pursh.) May. St. Croix. Viburnum acerifolium, (L.) "Grand Portage Trail" from Lake Superior to the Upper St. Croix. Viburnum Opulus, (L.) May. St. Croix, north to Lake Superior. Cranberry bush. The fruit of this handsome and frequently prolific shrub, when freshly gathered, and fully ripe, furnishes a grateful repast to the traveller in these northern regions.

RUBIACEÆ.—Galium asprellum, (Michx.) Thickets. St. Croix. Galium trifidum, (L.) Small Bed Straw. Common. Galium triflorum, (Michx.) June. Rich woods. St. Peter's. Galium boreale, (L.) June. High prairies. St. Peter's. Cephalanthus occidentalis, (L.) Springy places. Common. Hedyotis longifolia, (Hook.) July. Exposed granite rocks. Upper St. Peter's. Falls of St. Croix. Mitchella repens, (L.) Pine woods. St. Croix.

VALERIANACEÆ.—Valeriana edulis, (Nutt.) Upper Mississippi. May. This widely-spread western plant, which was formerly described in Torrey and Gray's Flora as a distinct species, (V. ciliata,) is now

ascertained to be identical with the native of Oregon, so extensively used in that region as an article of diet, by the Indian tribes. Its thick fleshy root possesses, in a fresh state, the peculiar aromatic qualities which render most of the plants of this genus useful in medicine. This property being dissipated in the process of cooking, it is said to form a nutritious and palatable article of food. I am not informed of any similar application of this plant in the region of country under examination, but this may be accounted for from its comparative scarcity.

Compositæ.—Vernonia fasciculata, (Michx.) August. Iron weed. St. Croix. Liatris cylindracea, (Michx.) August. Dry hillsides. Iowa and Minnesota. Liatris scariosa, (Willd.) August. Dry rolling prairies. Iowa. Liatris pycnostachya, (Torr. and Gr.) Moist places in prairies. Iowa, and Minnesota. Kuhnia eupatorioides, (L.) September. Dry hills. Davenport, Iowa. Eupatorium purpureum, (L.) Low grounds. St. Croix. Eupatorium serotinum, (Michx.) September. Dry banks of rivers. Iowa. Eupatorium perfoliatum, (L.) Boneset. St. Croix, &c. Eupatorium ageratoides, (L.) August. Falls of St. Croix. Aster macrophyllus, (L.) Copses. Common throughout the Northwest. Aster sericeus, (Vent.) August. Dry prairies. Iowa. Barrens of St. Croix. A characteristic and handsome species, with silvery foliage and rich purple flowers. Aster lævis, (L.) August. Dry woodlands. Common. Aster azureus, (Lindl.) August. Dry hillsides. Iowa and Minnesota. Aster cordifolius, (L.) August. Thickets. St. Croix. Aster sagittifolius, (Willd.) August. Falls of St. Croix. Aster multiflorus, (Ait.) September. Dry fields. Iowa. Aster miser, (Ait.) August. Thickets. St. Croix. Aster puniceus, (L.) September. Moist ground. St. Croix. Aster laxifolius, (Nees.) August. Bogs. St. Croix. Aster oblongifolius, (Nutt.) June. Rocky banks of the Mississippi, near Davenport, Iowa. Aster ptarmicoides, (Torr. and Gr.) August. Dry river bluffs, Mississippi and St. Croix. Erigeron Canadense, (L.) A common weed springing up very rank on broken prairies, where cultivation has been abandoned. Erigeron bellidifolium, (Muhl.) May. Grassy places. Iowa and Minnesota. Erigeron Philadelphicum, (L.) June. Davenport, Iowa. Erigeron glabellum, (Nutt.) Upper St. Croix. Erigeron annuum, (Pers.) June. Davenport, Iowa. Erigeron strigosom, (Muhl.) St. Croix. Diplopappus umbellatus, (Torr. and Gr.) Thickets of St. Croix. Solidago bicolor, var. concolor, (Linn.) August. Trap rocks. Falls of St. Croix. Solidago latifolia, (L.) Shaded river-banks in the Northwest. Solidago stricta, (Ait.) August. Tamerack swamps. St. Croix. Solidago speciosa, (Nutt.) August. Dry, rolling prairies. Iowa and Minnesota. Solidago rigida, (L.) September. A conspicuous and common prairie plant. Solidago ulmifolia, (Muhl.) August. Falls of St. Croix. Solidago nemoralis, (Ait.) August. Dry hillsides. Iowa and Minnesota. Solidago serotina, (Ait.) August. Falls of St. Croix. Solidago lanceolata, (Ait.) August. St. Croix. Chrysopsis villosa, (Nutt.) July. Dry soil. Fort Snelling. Silphium laciniatum, (L.) July. Rosin weed, "Compass plant." Prairies of Iowa and Illinois. Silphium perfoliatum, (L.) Cup plant. Borders of streams. Iowa and Minnesota. Its large, coarse leaves, uniting at their insertion around the square stem, form a cup-shaped cavity, which retains the water after a shower. Ambrosia artemisifolia, (L.) Waste places. Ambrosia trifida, (L.) Growing with luxuriant rankness on the rich cultivated bottoms of the Mississippi. Xanthium strumarium, (L.) River-banks, St. Peter's. Heliopsis lævis, (Pers.) July. Banks of streams throughout the Northwest. Echinacea angustifolia, (D. C.) June. An abundant and striking prairie-flower in Iowa. Its thick, pungent root, under the name of "Black Sampson," has wonderful properties ascribed to it in popular medicine. Echinacea purpurea, (Mœnch.) July. Iowa prairies. Rudbeckia hirta, (L.) June. Dry soil. Iowa and Minnesota. Rudbeckia triloba, (L.) September. Dry hillsides. Iowa. Rudbeckia subtomentosa, (Pursh.) August. Wet places. Iowa. Rudbeckia laciniata, (L.) August. Copses. Iowa and Minnesota. Lepachys pinnata, (Torr. and Gr.) July. Dry prairies. Iowa and Minnesota. Helianthus rigidus, (Desf.) September. Abundant on dry prairies. Iowa. Helianthus occidentalis, (Riddell.) July. Dry hills. Davenport, Iowa, and St. Croix. Helianthus giganteus, (L.) August. Copses. St. Croix. Helianthus strumosus, (L.) Copses. Common. Helianthus tuberosus, (L.) Common artichoke. River-banks. St. Peter's and St. Croix. Certainly native, and a well-known article of diet among the Indians, called by the Chippewas, Ush-ke-buag. Like the red-currant, and hop, it furnishes another singular instance, in this region, of a native plant, which is soon destined, with the progress of civilization, to meet its cultivated compeer, coming from a far land. Actinomeris squarrosa, (Nutt.) September. Thickets. Iowa. Coreopsis tripteris, (L.) Borders of streams. Iowa. Coreopsis palmata, (Nutt.) June. Dry copses and prairies. Iowa and Minnesota. Bidens frondosa, (L.) Wet places. Common. Bidens chrysanthemoides, (Michx.) August. St. Croix. Bidens Beckii, (Torr.) Floating in shallow

lakes near the head waters of St. Croix River. Dysodia chrysanthemoides, (Lagasca.) August. Waste places about towns. Iowa. Helenium autumnale, (L.) Alluvial soil. Common. Maruta Cotula, (D. C.) May-weed. Abundantly naturalized about western towns. Achillea Millefolium, (L.) June. Sandstone rocks. Blue Earth River. Artemisia caudata, (Michx.) Dry prairies and river-banks. Iowa and Minnesota. Artemisia Ludoviciana, (Nutt.) Dry rolling prairies. Iowa and Minnesota. Artemisia biennis, (Willd.) Roadsides. Iowa. Artemisia dracunculoides? (Pursh.) Iowa and Minnesota. Gnaphalium decurrens, (Ives.) Old deserted fields. Lake Superior. Antennaria margaritacea, (R. Br.) Lake Superior. Antennaria plantaginifolia, (Hook.) April. Dry knolls throughout the Northwest. Erechthites hieracifolia, (Raf.) August. Trap-rocks. Falls of St. Croix. Cacalia reniformis, (Muhl.) Copses. Davenport, Iowa. Cacalia atriplicifolia, (L.) Davenport, Iowa. Cacalia tuberosa, (Nutt.) Indian plantain. Moist prairies. Iowa and Minnesota. The tubers, from which Mr. Nuttall derived the specific name of this plant, have not been noticed by other observers. Senecio integerrimus, (Nutt.) June. Alluvial bottoms of Blue Earth River. Senecio aureus, var. Balsamitæ, (L.) Rocky banks. Davenport, Iowa. Cirsium altissimum, (Spring.) Fall prairie thistle. Iowa and Minnesota. Cynthia Virginiana, (Don.) May. Dry hills. Davenport, Iowa. Hieracium Canadense, (Michx.) August. Trap-rocks at the Falls of St. Croix. Hieracium scabrum, (Michx.) August. Dry hillsides, St. Croix. Hieracium longipilum, (Torr.) This singular species was collected by Mr. Randall on the St. Croix, who was struck with its singular appearance, its long hairs beset with dew-drops, giving it the appearance of a Cactus. Nabalus albus, (Hook.) August. Edges of woods. St. Croix. Nabalus racemosus, (Hook.) September. Moist prairies. Iowa. Nabalus asper, (Torr. and Gr.) Dry prairies. Iowa. Lygodesmia juncea, (Don.) July. Drift-ridges on the Upper St. Peter's. A characteristic plant on the great western plains. Troximon cuspidatum, (Pursh.) April. Prairies of Iowa and Minnesota. Taraxacum densleonis, (Desf.) Dandelion. Lake Superior. Lactuca elongata, (Muhl.) Wild lettuce. St. Croix. Mulgedium leucophæcum, (D. C.) Low grounds. Common.

Lobeliaceæ.—Lobelia cardinalis, (L.) August. Low grounds. Iowa, &c. Lobelia syphilitica, (L.) August. St. Croix. Lobelia inflata, (L.) Indian tobacco. Lake St. Croix. Lobelia spicata, (Lam.) July. Prairies. St. Peter's.

Campanulaceæ.—Campanula rotundifolia, (L.) July. Sand-rock. St. Peter's. Campanula aparinoides, (Pursh.) July. Bogs. St. Croix. Campanula Americana, (L.) July. Woods. Iowa. Specularia perfoliata, (A. D. C.) June. Dry hills. Iowa.

Ericaceæ.—Gaylussacia resinosa, (Torr. and Gr.) Black Huckleberry. Found only in a single isolated locality, near Davenport, Iowa. Vaccinium macrocarpon, (Ait.) American cranberry. This staple native production of the Northwest is nowhere more abundant, or of finer quality, than in the region bordering the St. Croix River. In this section of lakes and swamps innumerable, this humble plant, with the commonly associated tamerack growth, offers some compensation for the obstacles nature seems to have thrown in the way of ordinary cultivation. The marshes in which it abounds are of the usual character in other parts, viz., a bed of sphagnum, sinking under the foot, so as to be knee-deep in water. The usual vegetable accompaniments are Andromeda polifolia and calyculata, Sarracenia purpurea, Menyanthes trifoliata, &c. The season of gathering the fruit lasts from September till snow-fall, and is quite an important business among the Indians. The susceptibility of this plant for cultivation being now abundantly proved, we may soon expect to see this wholesome and excellent fruit take an important rank in the commerce of this region. Vaccinium cæspitosum, (Michx.) Margins of a lake near Stillwater, St. Croix. Vaccinium Pennsylvanicum, (Lam.) Barrens on the Upper St. Croix. This is the common Huckleberry, associated with the characteristic growth of the Pinus Banksiana, covering its sandy ridges with a verdant undergrowth, and an unsurpassed luxuriance of fruit. By the Indians, these are collected and smoke-dried in great quantities, and in this form constitute an agreeable article of food. It seems strange that the species of this useful genus have not been made more the subject of horticultural examination. Vaccinium Canadense, (Kalm.) Falls of St. Croix. Chiogenes hispidula, (Torr. and Gr.) Mossy woods. Upper St. Croix. Arctostaphylus Uva-ursi, (Spreng.) Pine Barrens. St. Croix. Sandy shore of Lake Superior. The leaves of this well-known medicinal plant are frequently used as a substitute for Kinnikinnic. Gaultheria procumbens, (L.) Common wintergreen. Upper St. Croix. Pine Barrens. This abundant plant is frequently used as a substitute for common tea by the French voyageurs. Epigæa repens, (L.) Trailing arbutus. Upper St. Croix. Andromeda polifolia, (L.) May. Bogs and cranberry marshes. St. Croix. Andromeda calyculata, (L.) Bogs. St. Croix. Le-

dum latifolium, (Ait.) Marsh Tea. Margins of tamerack swamps. Upper St. Croix. Pyrola rotundifolia, (L.) Pine woods. St. Croix. Pyrola elliptica, (Nutt.) July. Traverse des Sioux, on the St. Peter's. Pyrola secunda, (L.) Pine woods. St. Croix. Chimophila umbellata, (Nutt.) Pipsissewa. Pine woods. St. Croix. Hypopithys lanuginosa, (Nutt.) Woods. Lake Superior. Monotropa uniflora, (L.) Woods. Lake Superior.

AQUIFOLIACEÆ.—Prinos verticillatus, (L.) St. Croix. The bark of this shrub is a common Indian emetic. Nemopanthes Canadensis, (D. C.) Boggy woods. St. Croix.

PLANTAGINACEÆ.—Plantago major, (L.) Common plantain. Plantago cordata, (Lam.) April. Edges of brooks. Iowa. Plantago gnaphaloides, (Nutt.) Bare granitic knolls. Upper St. Peter's.

PRIMULACEÆ.—Dodecatheon Meadia, (L.) Pride of the Prairie. Iowa. Trientalis Americana, (Pursh.) Woods. Upper St. Croix. Androsace occidentalis, (Pursh.) April. Banks of the Mississippi, near Davenport, Iowa. Lysimachia stricta, (Ait.) June. Borders of St. Croix. Lysimachia quadrifolia, (L.) Dry, sandy ridges. St. Croix. Lysimachia ciliata, (L.) Low grounds. St. Croix. Lysimachia lanceolata, (Walt.) Moist river-banks. St. Croix. Naumburgia thyrsiflora, (Reichenb.) Swamps. St. Peter's.

LENTIBULACEÆ.—Utricularia vulgaris, (L.) Ponds. Iowa. Utricularia intermedia, (Hayne.) Traverse des Sioux. St. Peter's.

OROBANCHACEÆ.—Philipæa Ludoviciana, (Walp.) July. Traverse des Sioux. Found in a singular isolated locality, rooting on an Indian grave. Anoplanthus fasciculatus, (Walp.) Bare granite rocks. Upper St. Peter's.

SCROPHULARIACEÆ.—Verbascum Thapsus, (L.) Mullein. Roadsides. Iowa. Scrophularia nodosa, (L.) June. Copses. Iowa and Minnesota. Chelone glabra, (L.) Swamps. Iowa and Minnesota. Pentstemon pubescens, (Solander.) June. Banks of the Mississippi. Davenport, Iowa. Pentstemon lævigatum, (Pursh.) Roadsides. Iowa. Pentstemon grandiflorum, (Nutt.) Dry hills about Fort Snelling. This large and handsome species, resembling in aspect the well-known Fox-glove, is equally worthy a place in the flower-garden. Mimulus ringens, (L.) Wet places. Common. Mimulus Jamesii, (Torr. and Gr.) Cold springs at Fort Snelling and Stillwater. This peculiar northwestern species is only found floating on the pure issue of the coldest springs, which it mats with its succulent foliage, continuing to put forth its yellow blossoms through the entire flowering season. Synthyris Houghtoniana, (Benth.) May. Abundant on the high table-land overlooking the town of Stillwater, St. Croix. This northwestern plant, so unique in its botanical features, is no less interesting in its association with the name of the lamented Houghton. Veronica Virginica, (L.) Culver's root. A common and conspicuous plant on rich prairies throughout the Northwest. It still retains some reputation as a popular medicinal agent. Veronica Americana, (Schwein.) Brooks. Iowa. Veronica scutellata, (L.) Bogs. Upper Mississippi. Veronica peregrina, (L.) Waste places. Davenport. Gerardia purpurea, (L.) August. Lake margins. St. Croix. Gerardia tenuifolia, (Vahl.) August. Falls of St. Croix. Gerardia Pedicularia, (L.) September. Dry prairies. Iowa. Castilleja coccinea, (Spreng.) June. Painted Cup. An abundant and showy prairie flower. Iowa. Castilleja sessiflora, (Pursh.) June. Drift ridges. St. Peter's. Pedicularis Canadensis, (L.) Prairies. Iowa and Minnesota. Melampyrum pratense, (L.) Pine Barrens. St. Croix.

VERBENACEÆ.—Verbena hastata, (L.) Waste places. Davenport, Iowa. Verbena urticifolia, (L.) Roadsides. Iowa. Verbena spuria, (L.) Dry fields. Iowa. Verbena angustifolia, (Michx.) June. Dry fields. Iowa. Verbena stricta, (Vent.) River-banks and prairies of Iowa. Verbena bracteosa, (Michx.) Roadsides. Iowa and Minnesota. Phryma leptostachya, (L.) Rich woods. Iowa and Minnesota. Lippia nodiflora, (Michx.) River-banks, Mississippi and Des Moines.

LABIATÆ.—Isanthus cæruleus, (Michx.) August. Gravelly banks. Iowa. Mentha Canadensis, (L.) Wild mint. Borders of streams. Lycopus Virginicus, (L.) Bugle-weed. Lake margins. St. Croix. Lycopus sinuatus, (Ell.) Water horehound. Springy places. Iowa and Minnesota. Hedeonia hirta, (Nutt.) Dry, exposed places. Iowa and Minnesota. Monarda fistulosa, (L.) Wild bergamot. Dry hills. St. Croix. A fragrant and handsome species. Nepeta Cataria, (L.) Catnip. Falls of St. Croix. Lophanthus anisatus, (Benth.) Thickets. St. Peter's, Fort Snelling, Falls of St. Croix. This characteristic northwestern species combines an agreeable anisate flavour, with a singular beauty of flowers and foliage. In both respects it deserves a place in every garden. Its essential oil would make a useful addition to our number of such articles, and it would be interesting to compare it with the

common Anise, belonging to a very distinct family, which this plant so closely resembles in taste. Lophanthus nepetoides, (Benth.) Falls of St. Croix. Lophanthus scrophularifolius, (Benth.) All three of the above species are found side by side at the Falls of St. Croix, and exhibit a fine example of gradation of specific characters. Pycnanthemum pilosum, (Nutt.) Dry hills. Iowa. Pycnanthemum lanceolatum, (Pursh.) Thickets in Iowa and Minnesota. Prunella vulgaris, (L.) Common Heal-all. Scutellaria parvula, (Michx.) May. Gravelly borders of the Upper Mississippi. Scutellaria galericulata, (L.) Wet places. St. Croix. Scutellaria laterifolia, (L.) Wet places. Iowa and Minnesota. Scutellaria versicolor, (Nutt.) Copses. Davenport, Iowa. Physostegia Virginiana, (Benth.) July. River margins. Upper Mississippi, St. Peter's, and St. Croix. Leonurus Cardiaca, (L.) Mother-wort. About houses. Galeopsis Tetrahit, (L.) Lake Superior. Stachys hispida, (Pursh.) Margins of rushy ponds. Iowa. Teucrium Canadense, (L.) Low grounds. St. Croix.

Boraginaceæ.—Onosmodium molle, (Michx.) About gopher-holes, on prairies. Iowa and Minnesota. Lithospermum latifolium, (Michx.) May. Rock Island, Illinois. Batschia Gmelini, (Michx.) June. Dry, sandy ridges. Iowa and Minnesota. Batschia canescens, (Michx.) Hoary Puccoon. More abundant than the preceding species, and growing on richer soil. Its root furnishes a common dye, used by the Indians. Batschia longiflora, (Nutt.) May. Banks of the Mississippi River, near Davenport, Iowa. Mertensia Virginica, (D. C.) April. Lung-wort. Davenport. Echinospermum Lappula, (Lehm.) Stick-seed. Waste places. Cynoglossum officinale, (L.) Hound's-tongue. Roadsides. Cynoglossum Virginicum, (L.) Portage between the St. Croix and Bois Brulé Rivers. Cynoglossum Morisoni, (D. C.) Waste places about villages. Iowa.

Hydrophyllaceæ.—Hydrophyllum Virginicum, (L.) June. Rich woods. Iowa and Minnesota. Hydrophyllum appendiculatum, (Michx.) June. Copses. Iowa. Ellisia ambigua, (Nutt.) May. An evanescent weed, common about cultivated fields and gopher-holes. Iowa and Minnesota.

Polemoniaceæ.—Polemonium reptans, (L.) May. Shady places, near Davenport, Iowa. Phlox maculata, (L.) June. Wet places on prairies. Iowa. Phlox pilosa, (L.) June. Common on prairies throughout the Northwest. Phlox divaricata, (L.) April. Shady hillsides. Iowa.

Convolvulaceæ.—Calystegia sepium, (R. Br.) Bindweed. Copses. Iowa and Minnesota. Cuscuta Gronovii, (Willd.) Common dodder. Low grounds. Cuscuta glomerata, (Choisy.) Mississippi bottoms, near Rock Island, Illinois.

Solanaceæ.—Datura Stramonium, (L.) Waste places, interior of Iowa. A close attendant on the steps of the pioneer physician. Physalis viscosa, (L.) Dry fields, Iowa and St. Peter's. A narrow-leaved variety, which is often confounded with the P. lanceolata of Michaux, is frequently met with. Solanum nigrum, (L.) Waste places. St. Croix.

Gentianaceæ.—Gentiana quinqueflora, (Lam.) Dry prairies, Iowa. Gentiana crinita, (Frœl.) Fringed gentian. Moist grounds, St. Croix. Gentiana Saponaria, (L.) Moist river banks. Upper St. Croix. A pure white variety is often met with. Menyanthes trifoliata, (L.) Bogs. St. Croix and St. Peter's. Halenia deflexa, (Griseb.) Bois Brulé River bank and south shore of Lake Superior.

Apocynaceæ.—Apocynum androsæmifolium, (L.) June. St. Croix. Apocynum cannabinum, (L.) River-banks throughout the Northwest.

Asclepiadaceæ.—Asclepias Cornuti, (De Caisne.) Copses of the Northwest. Asclepias phytolaccoides, (Pursh.) Copses. St. Croix. Asclepias purpurascens, (L.) Hills. Davenport, Iowa. Asclepias obtusifolia, (Michx.) Dry, sandy prairies, Iowa. Asclepias Meadii, (Torr.) June. Of a singular isolated habit, but not rare on dry, rolling prairies. Iowa. Asclepias incarnata, (L.) Swamps. Iowa and Minnesota. Asclepias tuberosa, (L.) Butterfly-weed. June. Dry prairies. Iowa and Minnesota. Asclepias verticillata, (L.) Dry hills. Davenport, Iowa. Acerates longifolia, (Ell.) Moist places, Iowa. Acerates viridiflora, (Ell.) June. Dry hills and prairies. Iowa and Minnesota.

Oleaceæ.—Several species of Ash (Fraxinus), were observed, but I have not the means at hand for identifying them.

Aristolochiaceæ.—Asarum Canadense, (L.) Wild ginger. Rich woods. Iowa and Minnesota.

Chenopodiaceæ.—Chenopodium album, (L.) Cultivated fields. Iowa. Chenopodium hybridum, (L.) St. Croix. Blitum capitatum, (L.) La Pointe. Lake Superior. Acnida cannabina, (L.) St. Croix. River margins.

Amaranthaceæ.—Amaranthus hybridus, (L.) Fields and gopher-holes. Iowa and Minnesota. Amaranthus græcizans, (L.) A weed springing up wherever there is a garden.

NYCTAGINACEÆ.—Oxybaphus nyctaginea, (Torr.) Rocky river-banks. Upper Mississippi and St. Peter's. Oxybaphus angustifolius, (Torr.) Sandy bluffs. St. Croix. Oxybaphus hirsutus (?), (Hook.) Prairies. St. Peter's.

POLYGONACEÆ. Polygonum Pennsylvanicum, (L.) Moist places. St. Croix. Polygonum Persicaria. (L.) Moist places. St. Croix. Polygonum Hydropiper, (L.) Water pepper. St. Croix. Polygonum amphibium, (L.) July. Edges of shallow lakes. St. Croix. Polygonum aviculare, (L.) Door-weed. Common. Polygonum articulatum, (L.) Joint-weed. Sandy barrens. St. Croix. Polygonum Virginianum, (L.) August. St. Croix. Polygonum arifolium, (L.) Ditches. Common. Polygonum sagittifolium, (L.) With the preceding. Polygonum Convolvulus, (L.) Waste grounds. Polygonum cilinode, (Michx.) Shores of Lake Superior. There is a singular variety of this species which runs over the ground, its short axillary branches rooting at the extremity. Common to the steep bluffs of Lake Superior, and the Alpine regions of Northern New York. Polygonum dumetorum, (L.) Moist thickets. St. Croix. Rumex Hydrolapathum, (Hudson.) Wet, springy places. St. Croix. Rumex crispus, (L.) Davenport, Iowa. Rumex Acetosella, (L.) La Pointe. Lake Superior.

LAURACEÆ.—Benzoin odoriferum, (Nees.) Southern Iowa.

THYMELACEÆ.—Dirca palustris, (L.) Moose-wood. St. Croix woods.

ELÆAGINACEÆ.—Shepherdia Canadensis, (Nutt.) Shore of Lake Superior.

SANTALACEÆ.—Comandra umbellata, (Nutt.) Dry banks, Iowa and Minnesota.

EUPHORBIACEÆ.—Euphorbia platyphylla, (L.) Dry fields. Davenport, Iowa. Euphorbia corollata, (L.) Flowering spurge. Dry prairies of Iowa to St. Peter's. A striking feature of the prairie landscape, with its spreading umbel of minute flowers, continually put forth from June to September. It is an emetic in common use among the Indians of the Northwest, attended frequently with fatal effects, from the violence of its action. Euphorbia maculata, (L.) Falls of St. Croix. Euphorbia hypericifolia, (L.) Waste dry places. St. Croix. Acalypha Virginica, (L.) Gravelly river-banks. Pilinophytum capitatum, (Kl.) August. Streets of Davenport, Iowa. Leaves aromatic.

JUGLANDACEÆ.—Juglans nigra, (L.) Interior of Iowa. Juglans cinerea, (L.) Falls of St. Croix. Carya alba, (Nutt.) Iowa.

CUPULIFERÆ.—Ostrya Virginica, (Willd.) Iron-wood. St. Croix. Carpinus Americana, (Michx.) Falls of St. Croix. Corylus Americana, (Wait.) Hazelnut. Forming thickets on rich prairies, Iowa. An index of a fruitful soil. Corylus rostrata, (Ait.) St. Peter's. Quercus. Several species.

MYRICACEÆ.—Myrica Gale, (L.) Bay berry. Moist margins of the Upper St. Croix. Comptonia asplenifolia, (Ait.) Pine barrens and aspen thickets. Upper St. Croix.

BETULACEÆ.—Betula papyracea, (Ait.) Canoe birch. St. Croix and Lake Superior. Betula pumila, (L.) Edges of bogs. St. Croix. Alnus incana, (Willd.) Springs and swamps. St. Croix.

SALICACEÆ.—Salix candida, (Willd.) Bogs. St. Croix. Salix longifolia, (Muhl.) Sandbar Willow. Salix pedicellaris, (Pursh.) Swamps. St. Croix. Populus tremuloides, (Michx.) Aspen. Forming close thickets. St. Peter's and St. Croix. Populus grandidentata, (Michx.) Iowa.

URTICACEÆ.—Humulus Lupulus, (L.) Common hop. Native on all the tributaries of the Upper Mississippi. Mr. Nuttall considers it a distinct species. Urtica gracilis, (Ait.) Falls of St. Croix. Urtica Canadensis, (L.) Wooded banks of the St. Peter's. It is of this plant the Indians usually make their fishing-lines; the rotted remains of the previous year's growth, furnishing an abundant extemporaneous supply. Pilea pumila, (Gray.) Springy places. St. Croix.

CONIFERÆ.—Pinus resinosa, (Soland.) Red pine. St. Croix. Pinus Strobus, (L.) White pine. Tributaries of the Upper Mississippi, on the eastern side. Pinus Banksiana, (L.) Barrens. Upper St. Croix. Abies Canadensis, (Michx.) Hemlock tree. Lake Superior. Abies nigra, (Michx.) Black spruce. Lake Superior. Abies alba, (Michx.) Upper St. Croix. Larix Americana, (Michx.) Tamerack. Upper St. Croix. Thuya occidentalis, (L.) White cedar. Lake Superior. Juniperus Virginiana, (L.) Red Cedar. Upper Mississippi. Taxus Canadensis, (Willd.) American yew. Upper St. Croix and Lake Superior.

ENDOGENS.

ARACEÆ.—Arum triphyllum, (L.) May. Woods. Iowa and Minnesota. Calla palustris, (L.) July. Bogs. St. Croix. Symplocarpus fœtidus, (Salisb.) Skunk cabbage. Swamps. Iowa. Not

common. Acorus Calamus, (L.) Sweet flag. The leaves of this common swamp plant are in frequent use among the Indians in the construction of mats.

Lemnaceæ.—Lemna trisulca, (L.) Pools. St. Peter's.

Typhaceæ.—Typha latifolia, (L.) Cat-tail. Ponds, and lakes. The down of the full-blown seed is used by Indian mothers as padding for the clothes of young infants, to protect them from the cold. Sparganium Americanum, (Nutt.) Muddy places. St. Croix. Sparganium natans, (L.) Brooks. St. Croix.

Naiadaceæ.—Potamogeton natans, (L.) Lake-like expansions of the Upper St. Peter's and St. Croix.

Alismaceæ.—Alisma plantago, (L.) Swamps. Upper St. Peter's. Echinodorus subulatus, (Engelm.) Muddy margins of ponds. St. Croix. Sagittaria variabilis, (Engelm.) Shallow ponds and muddy margins of lakes and rivers throughout the Northwest. This plant, so variable in foliage, and so abundant in distribution, furnishes an important article of native food in the tubers which beset its fibrous roots. These tubers (from the fact of their affording nourishment to the larger aquatic fowls, which congregate in such abundance about the northwestern lakes) are called by the Chippewas, Wab-es-i-pin-ig, or swan potatoes, a name which has been naturally appropriated to several streams of this region, Wabesipinicon; meaning, the abode of the swan potato. These tubers frequently attain the size of a small hen's-egg, and are then eaten by the Indians, with whom they are a great favourite. In their raw state they contain a bitter, milky juice, but in boiling become sweet and palatable. Triglochin elatum, (Nutt.) Upper St. Peter's. Scheuchzeria palustrus, (L.) Bogs. St. Croix.

Orchidaceæ.—Microstylis monophyllos, (Lindl.) Springy swamps. St. Croix. Microstylis ophioglossoides, (Nutt.) Damp woods. St. Croix. Orchis spectabilis, (L.) May. Woods. Rock Island, Illinois. Platanthera Hookeri, (Lindl.) Woods. St. Croix. Platanthera dilatata, (Lindl.) Springy swamps. St. Croix. Platanthera leucophœa, (Nutt.) Moist places on prairies. Iowa. Platanthera psycodes, (Gray.) Swamps. St. Croix. Pogonia ophioglossoides, (Nutt.) Cranberry marshes. St. Croix. Calophogon pulchellus, (R. Br.) June. Bogs, and moist sandy places. Iowa and Minnesota. Spiranthes gracilis, (Bigelow.) Pine barrens. St. Croix. Spiranthes cernua, (Richard.) Wet, grassy places. St. Peter's. Goodyera pubescens, (R. Br.) Hemlock woods, on Lake Superior. Cypripedium pubescens, (Willd.) Yellow moccasin flower. Hillsides and prairies. Iowa and Minnesota. Cypripedium candidum, (Muhl.) Moist banks. Iowa. Cypripedium spectabile, (Swartz.) June. Shady hills, near Davenport, Iowa. Blue Earth River. Cypripedium acaule, (Ait.) Woods. St. Croix.

Amarilidaceæ.—Hypoxis erecta, (L.) Dry soil. Iowa and Minnesota.

Iridaceæ.—Iris versicolor, (L.) Swamps. Iowa and Minnesota. Sisyrinchium Bermudianum, (L.) Blue-eyed grass. May. Prairies of Iowa.

Dioscoreaceæ.—Dioscorea villosa, (L.) Wild yam root. Thickets. Iowa and Minnesota. A twining diœcious vine, the tortuous echinate root said to prove an efficacious remedy in bilious colic. (Ridell.)

Liliaceæ.—Smilax rotundifolia, (L.) June. Thickets on the banks of the St. Peter's. Smilax hispida, (Muhl.) St. Peter's river bottoms. Smilax herbacea, (L.) June. St. Peter's and St. Croix. Trillium cernuum, (L.) May. Lake St. Croix. Trillium sessile, (L.) May. Rich woods and copses. Davenport, Iowa. Not extending far to the north. A singular anomalous specimen has been noticed, illustrating the tendency to correspondence of parts, even when reverting from the original type. Thus, in place of the ordinary number, three, running through the several parts of the flower, there are in the specimen alluded to, four leaves, four sepals, four petals, eight stamens, and four pistils. Polygonatum pubescens, (Pursh.) River-banks. Mississippi and St. Peter's. Smilacina racemosa, (Desf.) June. Copses. St. Peter's. Smilacina stellata, (Desf.) Moist places in prairies. Iowa. Smilacina bifolia, (Ker.) May. Pine woods. St. Croix. Clintonia borealis, (Raf.) Moist woods. St. Croix. Ornithogalum umbellatum, (Linn.) May. Fields. Davenport, Iowa. Scilla esculenta, (Ker.) Wild hyacinth. Fields. Davenport, Iowa. The root of this elegant flowering plant, closely resembles an onion in shape, generally attaining the size of a hickory-nut, and possessing a pleasant, mucilaginous taste. This, or a closely allied species, extends to the Rocky Mountains, and constitutes an article of diet among the Indian tribes. Allium Canadense, (Kalm.) Wild onion. Rich hillsides. Iowa. Allium triflorum, (Raf.) June. Mountain leek. Shady and rich hillsides. St. Peter's and St. Croix. Lilium Philadelphicum, (L.) June. Rolling prairies of Iowa and Minnesota. Lilium Canadense, (L.) July. Swamps. St. Peter's. Erythronium albidum, (Nutt.) April. Davenport, Iowa.

Melanthaceæ.—Uvularia grandiflora, (Smith.) May. Hills and vales. Iowa. Uvularia sessifolia, (L.) Woods and copses. Iowa. Zigadenus glaucus, (Nutt.) June. Prairies. St. Peter's. Tofieldia glutinosa, (Willd.) Moist grounds near Stillwater, Minnesota.

Juncaceæ.—Juncus tenuis, (Willd.) Moist roadsides. Common. Juncus Conradi, (Tuckerm.) St. Croix. Juncus nodosus, (L.) Edges of ponds.

Pontederiaceæ.—Pontederia cordata, (L.) Mouth of Bad River. Lake Superior.

Commelynaceæ.—Tradescantia Virginica, (L.) Copses and grassy hills. Iowa and Minnesota.

Cyperaceæ.—Cyperus diandrus, (Torr.) Sandy soil. St. Croix. Cyperus inflexus, (Muhl.) Moist ground. St. Croix. Cyperus strigosus, (L.) Edges of ponds, &c. Cyperus filiculmis, (Vahl.) Dry, sandy soil. St. Peter's. Cyperus alterniflorus, (Schwein.) Sandy ridges. St. Croix. Dulichium spathaceum, (Pers.) Edges of ponds. St. Croix. Eleocharis palustris, (R. Br.) St. Croix. Eleocharis acicularis, (R. Br.) St. Croix. Scirpus lacustris, (L.) Bulrush. In common use among the Indians for making mats. Scirpus atrovirens, (Muhl.) Wet, grassy places. Scirpus Eriophorum, (Michx.) Moist grounds. Eriophorum Virginicum, (L.) Cranberry marshes. Eriophorum polystachyum, (L.) Tamerack marshes. Carex lanuginosa, (Michx.) Carex Meadii, (Dew.) Carex longirostris, (Torr.) Carex siccata, (Dew.) Carex aristata, (R. Br.) Carex varia, (Muhl.) Carex stricta, (Lam.) Carex rosea, var. radiata, (Dew.) Carex straminea, var. minor, (Dew.) Carex grisea, (Wahl.) Carex Sartwellii, (Dew.) Carex lacustris, (Willd.) Carex vulpinoidea, (Michx.)

Gramineæ.—Zizania aquatica, (L.) Wild rice. "Pshu," of the Sioux; "Manomin," of the Chippewas. This aquatic grass, not uncommon in the Northern United States, acquires in the Northwest an economical importance second to no other spontaneous production. It is the only instance in this region of a native grain, occurring in sufficient quantity to supply the wants of ordinary consumption. It is particularly abundant on the lake-like expansions of rivers, towards their sources, which give such a marked feature to the distribution of these northern streams, and is so grandly illustrated in their main type, the Mississippi. It seems to select, by preference, the lower terminations of these expansions, which generally debouch by a narrowed outlet, and considerable fall, constituting rapids. It is in these situations best exposed to the proper degree of inundation, and finds a suitable bed of the slimy sand, in which it grows most readily. It is rarely met with on inland lakes which have no outlet. As an article of food it is highly palatable and nutritious, being generally preferred to the commercial rice. The grain is long, slender, of a brown colour. In boiling, it puffs out to a pultaceous mass, and increases its bulk several times. It flowers in August, and is ready for gathering in September, which is conveniently done in canoes, the standing stalks being bent over the sides, and the grain beaten in. Its productive fields, at this season, harbour a great number of wild fowls, which obliges those who wish to secure a full crop, to anticipate the gathering season, by tying up the standing grain into bundles, which gives at the same time a claim to the crop. When gathered, it is subjected to a process of parching and thrashing, which, with the imperfect means at the command of the Indians, is the most tedious part of the business. This grain has been frequently introduced to the attention of cultivators, and is worthy of notice, not only for the value of its products, but the peculiar nature of the soil to which it is adapted, being necessarily unfit for any of our ordinary cultivated grains. As a native of the Northwest, it is undoubtedly susceptible of increased production, and will doubtless ere long constitute as important an element in the civilized wealth of this region, as it now does in adding to the comforts of its wild inhabitants. Alopecurus geniculatus, (L.) var. aristulatus. Wet places. St. Peter's. Stipa juncea, (L.) Porcupine grass. Rolling prairies of Iowa and Minnesota. Aristida tuberculosa, (Nutt.) Pine barrens. St. Croix. Muhlenbergia glomerata, (Trin.) St. Croix. Vilfa heterolepis, (Gray.) Agrostis Michauxii, (Trim.) Calamagrostis Canadensis, (Beauv.) St. Croix. Spartina cynosuroides, (Willd.) St. Peter's, &c. Bouteloua racemosa, (Lag.) Dry, exposed places. Iowa and Minnesota. Bouteloua oligostachya, (Torr.) Drift ridges. St. Peter's. Interior of Iowa. Bouteloua papillosa, (Engelm.) Sandy hillsides. St. Croix. A lately described species. Kœleria cristata, (Pers.) Dry prairies. Iowa and Minnesota. Glyceria Canadensis, (Trin.) Bogs. St. Croix. Poa compressa, (L.) Blue grass. Iowa and Minnesota. An introduced grass, following closely on the steps of the pioneer husbandman. Bromus ciliatus, (L.) St. Croix. Triticum repens, (L.) Fields. Iowa. Elymus Canadensis, (L.) River-banks. St. Peter's. Elymus Hystrix, (L.) Woods. St. Peter's. Hordeum jubatum, (L.) Squirrel-tail grass. Dry soil. Iowa and Minnesota. Hierochloa borealis, (Rœm. and Schult.) Junction of the St. Croix and Mississippi Rivers. Panicum capillare, (L.) Sandy soil. Iowa. Panicum latifolium, (L.) Thickets.

St. Peter's. Panicum pauciflorum, (Ell.) Panicum virgatum, (L.) Cenchrus echinatus, (L.) Burr grass. Sandy soil. Iowa. Andropogon furcatus, (Muhl.) Dry prairies. Common. Sorghum nutans, (Gray.) Dry soil. Iowa and Minnesota.

ÆROGENS.

Equisetaceæ.—Equisetum arvense, (L.) April. Damp places. Common. Equisetum sylvaticum, (L.) May. St. Peter's. Equisetum limosum, (L.) Shallow water. St. Peter's and St. Croix. Equisetum hyemale, (L.) Scouring rush. Very abundant, and rank, on the wooded banks of the St. Peter's, above high-water mark. Equisetum variegatum, (Schleicher.) Margins of Montreal River, Lake Superior. Equisetum scirpoides, (Michx.) Deep woods. St. Croix.

Filices.—Polypodium vulgare, (L.) Crevices of exposed rocks of every character. St. Peter's and St. Croix. Polypodium Phegopteris, (L.) Damp woods. St. Croix. Polypodium Dryopterus, (L.) Damp woods, under the shade of evergreens. St. Croix and Lake Superior. Struthiopteris Germanica, (Willd.) Alluvial soil, exceedingly rank on the bottoms of the Lower St. Peter's. Allosorus gracilis, (Presl.) Shaded rocks, Davenport, Iowa, Blue Earth River, head of Lake St. Croix. Pteris Aquilina, (L.) Common brake. Dry soil. Pteris atropurpurea, (L.) Attached principally to the Magnesian Limestones, Upper and Lower. Adiantum pedatum, (L.) Maiden-hair. Common. Camptosorus rhizophyllus, (Link.) Walking fern. Shaded and detached rocks, Falls of St. Croix. This fern sends forth roots at the extremity of each prolonged leaf, producing a bunch similar to the parent root, whence its name of walking-fern. Asplenium thelypteroides, (Michx.) Shady woods. St. Croix. Asplenium Filix-fœmina, (R. Br.) Moist woods. Common. Cystopteris bulbifera, (Bernh.) Wet rocks. Blue Earth River. Cystopteris fragilis, (Bern.) Shaded cliffs, St. Peter's and St. Croix. Woodsia obtusa, (Torr.) Trap-rocks. Falls of St. Croix. Woodsia Ilvensis, (R. Br.) Exposed granite and quartzite rocks. Upper St. Peter's. Cheilanthes vestita, (Willd.) Rocks. Falls of St. Croix. Dryopteris Thelypteris, (Gray.) Moist thickets. St. Croix. Dryopteris dilatata, (Gray.) Ravines. Falls of St. Croix. Dryopteris cristata, (Gray.) Alder swamps. St. Croix. Aspidium fragrans, (Sw.) Trap-rocks. Falls of St. Croix. Frond bipinnate, oblong-lanceolate; pinnæ oblong, slightly tapering to a very obtuse point, regularly opposite and alternate, closely set on the stipe; pinules oblong, obtuse, round-toothed. Sori attached in two rows, corresponding to the lobes formed by the teeth, nearer the midrib than margins of the pinnæ, mostly covering the lower surface of the frond; stipe thickly clothed at its lower part with brownish, unequal, ovate-acuminate scales. The whole fern beset with fragrant, glandular hairs. Growing in dense tufts, in the shaded crevices of trap-rocks, with the withered remains of several years' growth still adhering. The fronds are of a deep green colour above, paler below, four to nine inches high. The aroma is permanent and agreeable. I am informed by Dr. Torrey that this species has never before been found within the limits of the United States, but has been obtained in British America and Kamschatka, where it is used for making tea. In the locality here specified, it is quite abundant. Polystichum acrostichoides, (Schott.) Shady river-banks. Davenport, Iowa, and Fort Snelling. Onoclea sensibilis, (L.) Moist, springy places. Common. Osmunda spectabilis, (Willd.) Swamps. Upper St. Croix. Osmunda Claytoniana, (L.) Rich hillsides. St. Croix. Botrychium lunarioides, (Sw.) Low grounds. St. Croix. Botrychium Virginicum, (Sw.) Rich woods. St. Peter's.

Lycopodiaceæ.—Lycopodium lucidulum, (Michx.) Deep woods. St. Croix. Lycopodium annotinum, (L.) Woods. Lake Superior. Lycopodium clavatum, (L.) Upper St. Croix. Lycopodium dendroideum, (Michx.) Upper St. Croix. Lycopodium complanatum, (L.) Pine barrens. St. Croix. Selaginella rupestris, (Spring.) Exposed granite rocks, Upper St. Peter's; trap rocks, Falls of St. Croix.

Musci.*—Sphagnum cymbifolium, (Ehrh.) Cranberry marshes. Dicranum scoparium, (Hedw.) Lake Superior. Leucobryum vulgare, (Hampe.) Trap rocks. St. Croix. Atrichum angustatum, (Beauv.) Lake Superior. Bartramia pomiformis, (Hedw.) Montreal River. Mnium punctatum, (Hedw.) Cedar swamps. St. Croix. Mnium affine, (Blandon.) Decaying logs. Lake Superior. Bryum roseum, (Schreb.) Lake Superior. Isotherum minus, (Beauv.) Adhering to the trunk of the Swamp Ash. Hypnum populeum, (Hedw.) Red sand-rock. Lake Superior. Hypnum Schreberi,

* Determined by William S. Sullivant, of Columbus, Ohio.

(Willd.) Lake Superior. Hypnum tamariscinum, (Hedw.) Decaying logs. Lake Superior. Climacium dendroides, (Brid.) Matting, deep woods. Lake Superior.

Hepaticæ.—Marchantia polymorpha, (L.) Margins of brooks.

Lichenes.—Cladonia rangiferina, (Hoff.) Reindeer moss. Falls of St. Croix. Lake Superior. Gyrophora Muhlenbergii. Tripe de roche of the French voyageurs. Falls of St. Croix.

ARTICLE VI.

SYSTEMATIC CATALOGUE OF BIRDS OBSERVED IN NORTHERN WISCONSIN AND MINNESOTA.

BY HENRY PRATTEN.

ORDER I. ACCIPITRES.

Falconidæ.—Aquila, Brisson. The Golden Eagle, Aquila Chrysætos, Giraud. Haliætos, Savigny. The Brown or Bald Eagle, Haliætos Leucocephalus, Wilson. Buteo, Bechstein. Red-tailed, Hawk or Buzzard, Buteo Borealis, Gmelin. Nauclerus, Vigors. Swallow-tailed Hawk, Nauclerus Furcatus, Wilson. Falco, Linnæus. American Sparrow-hawk, Falco Sparverius, Bonaparte. Circus, Bechstein. Marsh Harrier, Circus Uliginosus, Wilson.

Strigidæ.—Bubo, Cuvier. The Great Horned Owl, Bubo Virginianus, Gmelin. The Little Screech Owl, Bubo Asio, Wilson. Ulula, Cuvier. The Barred Owl, Ulula Nebulosa, Linnæus.

ORDER II. PASSERES.

Caprimulgidæ.—Caprimulgus of Linnæus. The Whippoorwill, Caprimulgus Vociferus, Wilson. Chordeiles, Swainson. Night Hawk, Chordeiles Americanus, Wilson.

Hirundinidæ.—Hirundo, Linnæus. The Purple Martin, Hirundo purpurea, Linn., Gmelin. The White-bellied Swallow, Hirundo Bicolor, Vieillot. The Bank Swallow, Hirundo Riparia, Wilson, Bonap. The Cliff Swallow, Hirundo Fulva, Vieillot, Clinton, Bonaparte. On the Blue Earth River in great numbers.

Ampelidæ.—Bombycilla, Brisson. The Cedar Bird, Bombycilla Carolinensis, Bonaparte.

Alcedinidæ.—Alcedo, Linnæus. The Belted Kingfisher, Alcedo Alcyon, Linnæus. Trochilus, Linnæus. The Red-Throated Humming-Bird, Trochilus Colubris, Linn.

Certhidæ.—Sitta, Linnæus. The White-breasted Nuthatch, Sitta Carolinensis, Brisson. Troglodytes, Vieillot, Cuvier. The Wood Wren, Troglodytes Americanus, Audubon. The Mocking Wren, Troglodytes Ludovicianus, Bonaparte. Above Little Rock, on St. Peter's. The Short-billed Wren, Troglodytes Brevirostris, Nuttall.

Paridæ.—Parus, Linnæus. The Black Cap Tit, Parus Atricapillus, Linnæus.

Sylviadæ.—Sialia, Swainson. The Blue-bird, Sialia Wilsoni, Swainson.

Merulidæ.—Orpheus, Swainson. The Brown Thrush. Orpheus Rufus, Bonaparte. The Cat Bird. Orpheus Carolinensis, Linnæus, Giraud. Merula, Ray. American Robin, Merula migratoria, Linnæus, Richardson. The Wood Thrush, Merula Mustelina, Gmelin, Bonaparte. Blue Earth River. The Hermit Thrush, Merula Solitaria, Wilson, Richardson. Blue Earth River. Seiurus, Swainson. The Oven Bird, Seiurus Aurocapillus, Linnæus.

Sylvicolidæ.—Trichas, Swainson. The Yellow Throat. Trichas Marilandica, Wilson, Audubon. Vermivora, Swainson. The Golden-winged Warbler, Vermivora Chrysoptera, Linnæus. Sylvicola, Swainson. The Spotted Warbler, Sylvicola Maculosa, Gmelin. The Spotted Canada Warbler, Sylvicola Pardalina, Bonaparte. The Blackburnian Warbler, Sylvicola Blackburniæ, Lathm. The Summer Yellow Bird. Sylvicola Æstiva, Gmelin. The Chestnut-sided Warbler, Sylvicola Icterocephala, Linnæus.

Muscicapidæ.—Muscicapa, Linnæus. The American Redstart, Muscicapa Ruticilla, Linnæus. The Wood Pewee, Muscicapa Virens, Linnæus. Tyrannus, Vieillot. The King Bird, Tyrannus Intrepidus, Vieillot. The Great Crested King Bird, Tyrannus Crinitus, Linnæus.

Vireonidæ.—Vireo, Vieillot. The Red-eyed Greenlet, Vireo Olivaceus. Icteria, Vieillot. The Yellow-breasted Chat. Icteria Viridis, Gmelin, Bonaparte.

LANADÆ.—Lanius, Linnæus, Bonaparte. The Northern Butcher Bird, Lanius Septentrionalis, Gmelin.

CORVIDÆ.—Garrulus, Brisson. The Blue Jay, Garrulus Cristatus, Linnæus, Giraud. Corvus, Linnæus. The Common Crow, Corvus Americanus, Audubon. Quiscalus, Vieillot. Common Crow Blackbird, Quiscalus Versicolor, Vieillot. Icterus, Auctorum. The Golden Oriole, Icterus, Baltimore, Linnæus. The Red-winged Oriole, Icterus Phœniceus, Linnæus. The Yellow-headed Blackbird, Icterus Xanthocephalus, Bonaparte, Fort Snelling. Molothrus, Swainson. The Cow Bunting, Molothrus Pecoris, Gmelin. Dolichonyx, Swainson. The Boblink, Dolichonyx Oryzivorus, Linnæus.

FRINGILLIDÆ.—Coccoborus, Swainson. The Rose-breasted Grosbeak, Coccoborus Ludovicianus, Linnæus. Fringilla, Linnæus. The Song Sparrow, Fringilla Melodia, Wilson. The White-throated Sparrow, Fringilla Pennsylvanica, Brisson. Emberiza, Linnæus. Emberiza Pallida Audubon. Carduelis, Brisson. The Yellow-bird, or American Goldfinch. Carduelis Tristis, Linnæus. Pipilo, Vieillot. The Chewink, or Ground Robin, Pipilo Erythrophthalmus, Linnæus. Spiza, Bonaparte. The Indigo Bird, Spiza Cyanea, Linnæus. Pyranga, Vieillot. The Black-winged Red Bird, Pyranga Rubra, Linnæus. Blue Earth River.

PICIDÆ.—Picus, Linnæus. Red-headed Woodpecker, Picus Erythrocephalus, Linnæus. The Hairy Woodpecker, Picus Villosus, Linnæus. The Downy Woodpecker, Picus Pubescens, Linnæus. The Yellow-bellied Woodpecker, Picus Varius, Linnæus. The Golden-winged Woodpecker, Picus Auratus, Linnæus.

CUCULIDÆ.—Coccyzus, Vieillot. The Black-billed Cuckoo, Coccyzus Erythrophthalmus, Wilson.

COLUMBIDÆ.—Ectopistes, Swainson. The Wild Pigeon, Ectopistes Migratoria, Linnæus. The Carolina Turtle-Dove, Ectopistes Carolinensis, Linnæus.

ORDER III. GALLINÆ.

PHASIANIDÆ.—Meleagris, Linnæus. The Wild Turkey, Meleagris Gallopavo, Linnæus. Only found on the south of the Upper Iowa.

TETRAONIDÆ.—Ortyx, Stephens. The American Quail, Ortyx Virginiana, Linnæus. Tetrao, Linnæus. The Common Partridge, or Ruffed Grouse, Tetrao Umbellus, Linnæus. The Pinnated Grouse, or Prairie Hen, Tetrao Cupido, Linnæus.

ORDER IV. GRALLÆ.

CHARADRADÆ.—Charadrius, Linnæus. American King Plover, Charadrius semipalmatus, Bonaparte. Wilson's Plover, Charadrius Wilsonius, Ord, Bonaparte. The Killdeer Plover, Charadrius Vociferus, Linnæus. The Golden Plover, Charadrius Virginianus, Borkheim. Ardea. The Great Blue Heron, Ardea Herodias, Linnæus.

SCOLOPACIDÆ.—Totanus, Bechstein. The Spotted Sand Lark, Totanus Macularius, Linnæus. The Solitary Tatler, Totanus Chloropygius, Vieillot. The Gray Plover, Totanus Bartramius, Wilson. The Varied Tatler, or Tell-tale, Totanus Melanoleucus, Vieillot. Limosa, Brisson. The Marlin, Limosa Fedoa, Linnæus. Ortygometra, Aldrovandus, Leach. The Sora Rail, Ortygometra Carolina, Linnæus. Fulica, Gmelin. The American Coot, Fulica Americana, Gmelin.

ORDER V. NATATORES.

PELICANIDÆ.—Pelicanus. The White Pelican, Pelicanus Trachyrhyncus, Latham. Sterna, Linnæus. The Black Tern, Sterna Nigra, Linnæus.

ANATIDÆ.—Mergus, Linnæus. The Hooded Sheldrake, Mergus Cucullatus, Linnæus. Fuligula, Ray, Stephens. The Bastard Broadbill, Fuligula Rufitorques, Bonaparte. The Ruffle-headed Duck, Fuligula Albeola, Linnæus. Anas, Linnæus. The Wood Duck, Anas sponsa, Linnæus. The Blue-winged Teal, Anas Discors, Linnæus. The Green-winged Teal, Anas Carolinensis, Gmelin. The Mallard, Anas Boschas, Linnæus. Anser, Brisson. The Wild Goose, Anser Canadensis, Willoughby.

COLYMBIDÆ.—Colymbus, Linnæus. The Great Loon or Diver, Colymbus Glacialis, Linnæus.

TABLE OF STRATIGRAPHICAL AND GEOGRAPHICAL DISTRIBUTION OF GENERA AND SPECIES OF THE NORTHWEST.

	GENERA AND SPECIES.	PROTOZOIC = SILURIAN ROCKS. Lower. F. 1. Lowest Sandstones of Wisconsin and Iowa = Potsdam Sand'e, N. Y.	F. 2. Lower Magnesian Limestone = Calciferous Sandstone, N. Y.	F. 3, A. Shell-beds = Trenton Limestone, N. York.	F. 3, B. Lead-bearing beds of Upper Mag'n Limestone =	Utica Slate, N. Y.	Hudson River Group.	Upper. F. 3, C. Coralline and Pentamerus beds =	Clinton Group, N. Y.	Niagara Group, N. Y.	Limestones of Cedar and Iowa Valleys = Devonian Rocks = Onondaga Group, N. Y.	Corniferous Group, N. Y.	Hamilton Group, N. Y.	Carboniferous Limestones. Lower Series.	Upper Series.	LOCALITIES IN WISCONSIN, IOWA, AND MINNESOTA.	ELSEWHERE IN THE UNITED STATES AND CANADA.	EUROPE.	REFERENCES, SYNONYMS, AND REMARKS.
	CRUSTACEA (Trilobitis).																		
1	Dikelocephalus Minnesotensis.	*														Stillwater; La Grange Mt.; Miniskah.			Tab. I., figs. 1, 2, 10; I. A, figs. 1, 3, 6.
2	Miniscaensis.	*														Miniskah; Mt. Island.			Tab. I., fig. 3, a, b; I. A, fig. 5.
3	Pepinensis.	*														Head of Lake Pepin.			Tab. I., fig. 9, a, b; I. A, fig. 7.
4	(?) Iowensis.	*														Miss. River, below Mt. Island.			Tab. I., fig. 4.; I. A, fig. 13.
5	granulosus.	*														Miniskah.			Tab. I., figs. 7 and 5?
6	Lonchocephalus Chippewaensis.	*														Marine Mills and Menomonie River.			Tab. I., figs. 6, 14?, I. A, fig. 9.
7	hamulus.	*														Miniskah.			Tab. I. A, figs. 8, 12.
8	(Sp. undet.)	*														Near Mt. Island.			Tab. I. A, fig. 15.
9	Menocephalus Minnesotensis.	*														Miniskah.			Tab. I., fig. 11.
10	Crepicephalus Miniscaensis.	*														Miniskah.			Tab. I. A, figs. 10, 18.
11	Wisconsensis.	*														Mt. Island.			Tab. I., fig. 13.
12	Phillipsia (Sp. undet.)													*		Keokuk, Rapids of Mississippi.	Leavenworth, Ind.; Cloverport, Ky.		The pygidium (rather imperfect) is all that has been found; it is smaller than Portlock's fig. of this genus.
13	granulifera?													*		Augusta, Skunk River.			
14	pustulata.													*		Burlington?	North River, Mo.		
15	Calymene senaria.			*?			*									3 m. above Savannah; Bellevue.	Frankford, Maysville, Mount Wash'n, Ky.; Cincinnati, Oxford, Harrison, O.; Davidson Co., Ten.; Mad'n, Ia.		Tab. II. A, fig. 12.
16	crassimarginata.											*?	*?			3 m. below Rockingham.			Phacops crassimarginata, Tab. III. A., fig. 6.
17	(N. S.)			*?		*?										Otter Creek, Turkey River.			Tab. II. A., fig. 8.
18	Asaphus gigas.			*												Prairie du Chien; Fort Snelling; near Savannah.	Cincinnati, Ohio.		Isotelus gigas.
19	(N. S.?)			*?		*?										Red River, North.			
20	Iowensis.			*?		*?										Otter Creek.			Tab. II. A, figs. 1, 2, 3, 4, 5, 6, 7.
21	Illænus crassicauda.			*												Prairie du Chien; below Fort Snelling.	Lower F. Garry, Red R. of the N.; Middleville, Waterton, Turin, N. Y.; Carlisle, Pa.; Isle La Motte.	Shropshire and Montgomeryshire, England; Sweden; Husbyfjol, in E. Gothland; Osmunsberg; Esthonia, Revel, St. Petersburg.	
22	(S. undet.)					*										Wisconsin.			Geological Report of Survey of 1839, pl. 16, fig. 1.
23	ovalis.			*?												Prairie du Chien; 3 miles E. of Elkader Mill, Turkey R.; Big Spring.			
24	(N. S.)			*?		*?											Lower F. Garry, Red R., N.		Tab. II. A, fig. 10.
25	Ceraurus pleurexanthemus.			*												Prairie du Chien; Falls of St. Anthony.	Galena, Ill.; Middleville, Trenton Falls, Lowville, Waterton, N. Y.; Cincinnati, O.		Geological Report of Survey of 1839, pl. 17, fig. 11.
26	Phacops macrophthalma.												*			3 m. below Rockingham; Red Cedar; Wapsinonox.	Falls of Ohio; Columbus, O.		Odontopleura pleurexanthema.
27	(N. S.)			*												Ft. Atkinson, Turkey River.			
28	(N. S.)			*												Ft. Atkinson, Turkey River.			

29	Phacops callicephalus.			*						3 m. above Fort Snelling.	Hampshire, Va.; Cincinnati, O.; Trenton Falls, N. Y.		Calymene callicephalus.
30	Lichas (S. undet.)			*						Falls of St. Anthony.			
31	Cytherina (S. undet.)			*						" and Prairie du Chien.			
32	(N. S.?)			*?	*?						South bend of Red River N.		B. O. Tril., tab. II., figs. 9 and 10.
33	Bumastus Barriensis.			*						Agency, Turkey R.			Illænus Barriensis.
	CRINOIDEA.												
34	Platycrinus planus.							*		Burlington, Iowa.			Tab. V. A, fig. 4, *a*, *b*, *c*. Larger than any other species of this genus.
35	Yandellii.							*		" "	Salem, Ind.		Tab. V. A, fig. 6, *a*, *b*.
36	discoideus.							*		Augusta and Burlington, Iowa.			Tab. V. A, fig. 1.
37	corrugatus.							*		Burlington, Iowa.			Tab. V. A, fig. 2, *a*, *b*, *c*, *d*, *e*.
38	Burlingtonensis							*		" "			Tab. V. A, fig. 5.
39	Americanus.							*		" "			Tab. V. B, fig 1, *a*, *b*, in the oolitic layers.
40	Dichocrinus ovatus.							*		" "			Tab. V. A, fig. 9, *a*, *b*.
41	striatus.							*		" "			Tab. V. A, fig. 10, *a*, *b*, in the oolitic layers.
42	Cyathocrinus Iowensis.							*		" "			Tab. V. A, fig. 11, *a*, *b*, *c*.
43	cornutus.							*		" "			Tab. V. A, fig. 8, *a*, *b*. Rare.
44	Actinocrinus stelliformis.							*		" "			Tab. V. A, fig. 16, *a*, *b*. Rare.
45	unicornus.							*		" "			Tab. V. A, fig. 12, *a*, *b*.
46	Megistocrinus Evansii.							*		" "			Tab. VI. A, fig. 3, *a*, *b*. One of the largest discovered.
47	Poteriocrinus rhombiferus.							*		" "			Tab. V. B, fig. 2, *a*, *b*, *c*.
48	tumidus.							*			Chester, Ill.		Tab. V. B, fig. 3, *a*, *b*.
49	spinosus.							*			Kaskaskia, Ill.		Tab. V. B, fig. 4 in the pentremital layers.
50	occidentalis.							*			Chester, Ill.		Tab. V. B, fig. 5, *a*, *b*.
51	Agassizocrinus conicus.							*			" "		Tab. V. B, fig. 6.
52	Synbathocrinus dentatus.							*		" "			Tab. V. B, fig. 7, *a*, *b*.
53	Pentremites Norwoodii.							*		Burlington and Augusta, Iowa.	Oquaka, Ill.		Tab. V. A, fig. 13, *a*, *b*, *c*.
54	melo.							*		Burlington, Iowa.			Tab. V. A, fig. 14, *a*, *b*, *c*.
55	laterniformis.							*?	*?		Mill Creek, Randolph Co., Ill.		Tab. V. A, fig. 15.
56*	stelliformis.							*		Burlington, Iowa.			Tab. V. A, fig. 16.
86	Echino-encrinites anatiformis.			*						3 miles below Savannah; Fort Atkinson.	Trenton, N. Y.		Jour. Geo. Soc., Lond. Hall's Pal., p. 89, pl. 29, fig. 4.
87	Olivanites Verneuilii.						* *?			Near Rockingham.	Falls of the Ohio; Columbus, O.		
88	Heterocrinus heterodactylus.			*						3 miles above Savannah.			
89	Hexacrinus (S. undet.)						*			Davenport.			
90	Tentaculites (S. undet.)						*			3 miles below Rockingham.			
91	Melonites multipora.								*	St. Louis.			Jour. Acad. Nat. Sci., 1846, p. 225, figs. 1, 2, 3.
	CEPHALOPODA.												
92	Gonioceras anceps.			*						Mineral Pt.; Prairie du Chien.	La Salle Co., Ill.; Waterton, N. Y.		Vol. I. Hall's Palæontology, p. 54, pl. 14.
93	Gyroceras Burlingtonensis.							*		Burlington.			Tab. V., fig. 10.
94	Discites tuberculatus.								*	Iowa Point, Missouri R.			Tab. V., fig. 14.
95	Cyrtoceras macrostomum.				*					Fort Snelling; Agency, Turkey R.; Prairie du Chien; Mineral Point.	Middleville, N. Y.; Carlisle, Penn'a.		Hall's Pal. N. Y., p. 194, pl. 42, fig. 1.
96	conicum.				*					Mineral Point District.			Geol. Rep. of Survey of 1839, p. 47, pl. 17, fig. 9.
97	(S. undet.)				*	*				2 m. below Le Claire.			
98	(S. undet.)			*?	*					Turkey River.			
99	annulatum.			*									Hall's Pal., p. 194, pl. 14, figs. 4 and 5.
100	Lituites undatus?			*						Fort Snelling.	Waterton, N. Y.		Mould. Hall's Pal., pl. 13, fig. 1, in the Black. R. L.
101	convolvans.			*						Kinnikinick River.	" "		Mould. Hall's Pal., pl. 13, fig. 2, in Black. R. Limestone.
102	Orthoceras multicameratum?			*						4 miles above Dubuque.	Waterton, N. Y., in Birdseye Limestone.		Hortholus Americanus. The position of the syphon is a little different from that species. Hall's Pal., pl. 11, fig. 1.
103	undulostriatum?			*						Fort Atkinson.	Middleville, N. Y.		Hall's Pal., p. 202, pl. 43, fig. 7.
104	vertebrale.			*?	*						Middleville, N. Y.; Lower Ft. Garry, Red River N.		Hall's Pal., p. 201, pl. 43, fig. 5.
105	Campulites arcuatus?			*						Turkey River.		Lower Ludlow, Eng.	Phragmocerasarcuatum. Mur. Sil. Sys., pl. 10, fig. 1.

* Nos. 57 to 85—3 new genera and 29 species—remaining to be described.

TABLE, CONTINUED.

No.	GENERA AND SPECIES.	PROTOZOIC = SILURIAN ROCKS. Lower. F. 1. Lowest Sandstones of Wisconsin and Iowa = Potsdam Sand'e, N. Y.	F. 2. Lower Magnesian Limestone = Calciferous Sandstone, N. Y.	F. 3, A. Shell-beds = Trenton Limestone, N. York.	F. 3, B. Lead-bearing beds of Upper Mag'n Limestone =	Utica Slate, N. Y.	Hudson River Group.	Upper. F. 3, C. Coralline and Pentamerus beds =	Clinton Group, N. Y.	Niagara Group, N. Y.	Limestones of Cedar and Iowa Valleys = Devonian Rocks = Onondaga Group, N. Y.	Corniferous Group, N. Y.	Hamilton Group, N. Y.	Carboniferous Limestones. Lower Series.	Upper Series.	LOCALITIES IN WISCONSIN, IOWA, AND MINNESOTA.	ELSEWHERE IN THE UNITED STATES AND CANADA.	EUROPE.	REFERENCES, SYNONYMS, AND REMARKS.
	CEPHALOPODA (continued).																		
106	Campulites ventricosum.					*										Mineral Point District.		Lower Ludlow, Eng.	Orthoceratites and Phragmoceras ventricosum. Mur. Sil. Sys., pl. 10, figs. 4, 5, 6.
107	Endoceras proteiforme.			*												Falls of St. Anthony; Turkey River, above Dubuque.	Great Lake Winnipeg: Middleville, N. Y.		Hall's Pal., pl. 47 and 48.
108	subcentrale.			*												Turkey River; Mineral Point.	Waterton, N. Y.		Hall's Pal., p. 59, pl. 17, fig. 4, in Black R. Limestone.
109	Cuvieri.						*									Agency, Turkey River.	L. Ft. Garry, Red River N.; Middle Tenn.		Conotubularia Cuvieri. Mem. Geol. Soc. of France, T. III., p. 1, n. 4; pp. 87–90. Ormoceras tenuifillum. Hall's Pal., pl. 16, fig. 1.
110	Orthoceras junceum?			*												Fort Snelling and Prairie du Chien.	Waterton.		This fossil is larger than Hall's fig. 3, pl. 47, Pal., N. Y.
111	laqueatum.		*													Turkey River.	Calciferous Sandstone in New York.		Hall's Pal., pl. 3, fig. 12. The Iowa fossil occupies a higher position than in N. Y.
112	Trocholites ammonius.			*		*										Half a mile below Fort Snelling; near Prairie du Chien.	Trenton Limestone and Utica Slate, N. Y.		Hall's Pal., p. 193, pl. 40, A., fig. 4.
	GASTEROPODA.																		
113	Straparollus Minnesotensis.		*													Traverse des Sioux.			Tab. II., figs. 12 and 13.
114	(S. undet.)					*										Elkader.			Tab. II., fig. 14.
115	Maclurea magna.					*										Turkey River. 20 miles below Agency; Elkader Mill, Big Springs.	East Tennessee.		Straparollus magna. Hall's Pal., p. 26, pl. 5, fig. 1. This fossil occupies a higher position in Iowa than in Tenn. and N. Y.
116	Macrocheilus (N. S.?)					*										Turkey River, 20 miles below Agency.			Tab. II., fig. 9. Allied to Dev. sp. M. subcostata.
117	Pleurotomaria lenticularis.					*										Near Dubuque and Prairie du Chien; Elkader and Agency; Big Spring; Falls of St. Anthony.	Waterton, Middleville.	Caradoc Sandstone, Eng.	Trochus lenticularis. Mur. Sil. Sys., pl. 19, fig. 11. Hall's Pal., p. 172, pl. 37, fig. 6.
118	subconica.			*			*									Falls St. Anthony; F. Snelling.	Waterton, Turin, and Pulaski.		Hall's Pal., p. 174, pl. 37, fig. 8.
119	muralis.		*													" "	Lower Fort Garry, Red. R. N.		Tab. II., fig. 6.
120	umbilicata.		*?	*												" " "	Waterton (in Birdseye Limestone), Middleville, Adams, Turin, &c., N. Y; Cinc., O.		Hall's Pal., p. 175, pl. 38, fig. 1.
121	(N. S.)					*											Lower Ft. Garry, Red R.		
122	(S. undet.)			*												Prairie du Chien.			
123	(N. S.)			*												Prairie du Chien.			
124	(S. undet.)															3 miles below Rockingham.			
125	bilex.						*									Agency, Turkey River.	Frankfort, Mt. Washington, Maysville, Ky.; Cinc., O.		Hall's Pal., p. 307, pl. 83, fig. 4.
126	Murchisonia bellicincta.					*										Elkader Mill, Turkey R.; Big Springs; Prairie du Chien.	Waterton, Middleville, Trenton Falls, Turin, N. Y.		Hall's Pal., p. 179, pl. 39, figs. 1 and 4.
127	(S. undet.)					*										3 miles N. of Elkader.			
128	abbreviata.		*?			*										" "			Hall's Pal., p. 32, pl. 6, fig. 7.
129	subfusiformis.					*										Elkader; Big Springs.	Adams, Turin, N. Y.		Hall's Pal., p. 180, pl. 39, fig. 2.

130	Murchisonia tricarinata.									Falls of St. Anthony; 3 m. N. E. of Elkader; Prairie du Chien; Mineral Point.			Hall's Pal., p. 178, pl. 38, fig. 6.
131	Subulites elongata.									Prairie du Chien; 4 m. above Dubuque.			Hall's Pal., p. 182, pl. 39, fig. 3.
132	Holopea (S. undet.)				?					Elkader, Turkey River.			Allied to, but distinct from H. obliqua.
133	Bucania (N. S.)									Above Fort Snelling.			Allied to B. dorsata, but has no ridge on the dorsum.
134	Nerita (N. S.)									Missouri River, above Napoleon.	Below Fishing River.		
	HETEROPODA.												
135	Bellerophon hiulcus.										Keg Creek, Missouri R.; Eddyville, Ky.	Derbyshire; Visé, Tournay, Bel.	Tab. V., fig. 8. Sow. Min. Conch., 1. vol. V., p. 109, pl. 470, figs. 2 and 3.
136	(S. undet.)									3 m. below Rockingham.			
137	bilobatus.									Prairie du Chien; Big Springs, 4 miles above Dubuque.	Cincinnati, O.; Madison, Ind.; Middleville, Trenton, &c.; Glenn's Falls, &c., N. Y.	Caradoc, Llandeïlo;—Christiania.	Cyrtolithes bilobatus. Sow. Sil. Researches, 1839, p. 643, pl. 19, fig. 13. Hall's Pal., p. 184, pl. 40, fig. 3.
138	Cyrtolites ornatus.									Fort Snelling.			Tab. II. B, fig. 1.
139	compressus.									3 m. above Fort Snelling.	Middleville; Waterton.		Hall's Pal., p. 188, pl. 40, A, fig. 2.
	PTEROPODA.												
140	Conularia Trentonensis.										Middleville; Jacksonburgh.		Hall's Pal., p. 222, pl. 59, fig. 4.
141	(S. undet.)										Lower F. Garry, Red River N.		
	ACEPHALA.												
142	Ambonychia (undet.)									Ft. Snelling; Prairie du Chien.			Internal mould only found.
143	orbicularis.									" " "	Waterton, N. York; Madison, Ind.		Hall's Pal., p. 164, pl. 36, fig. 5. Pterinia and Posidonomya orbicularis.
144	(N. S.?)										Prairie du Chien.		Tab. II., fig. 19. Cast.
145	bellistriata?									Le Claire.	Trenton; Middleville, N. Y.		Posidonomya bellistriata D'Orb. Hall's Pal., p. 163, pl. 36, fig. 4.
146	obtusa.									Elkader Mill, Turkey River.	Waterton.		Posidonomya obtusa. D'Orb. Hall's Pal., p. 167, pl. 36, fig. 8.
147	(S. undet.)									Prairie du Chien.			
148	Pholadomia regularis?										Keg Creek, Missouri River.	Stolobinskoï, Rus.; Stoboda, Tarusa, Ylytsch, R.	Allorisma regularis. Tab. V., fig. 13.
149	Modiolopsis (undet.)									Prairie du Chien.			
150	Pleurorhynchus (N. S.?)										Lower Ft. Garry, Red River N.		Tab. II. B, fig. 19.
151	Sanguinolaria (undet.)									Burlington.			
152	Nucula levata.									Mineral Point.	Middleville, Jacksonburgh, Trenton Falls.	Llandeïlo flags?	Hall's Pal., p. 150, pl. 34, fig. 1. N. lævis. Sow. Sil. Re., p. 535, pl. 22, fig. 1.
153	Avicula (N. S.)							?	?	10 m. below F. Kearney, Mo. R.			
154	(S. undet.)							?	?	" " "			
155	(N. S.)									Augusta, Skunk River.			
156	Cardina nana.									Above Rac., F. Des Moines.		Liège, Bel.	Koninck, p. 71, pl. 1, fig. 6.
	BRACHIOPODA.												
157	{ Spirifer Lynx. }{ var. biforatus. }									Agency, Turkey River; Mineral Point, near Dubuque; G. L. Winnipeg.	Near Nashville, Tenn.; Jefferson Co. and Bullet Co., Maysville, Ky.; Cinc., O.; Madison, Ind.; Middleville, Trenton Falls, N. Y.	St. Petersburg.	Hall's Pal., p. 133, pl. 32, fig. 1. Delthyris Lynx and var. biforatus, N. Y. R.; var. T. chama. Eichwald.
158	(S. undet.)					?	?			Davenport.			Tab. III., fig. 7. Allied to S. undiferus.
159	glaber?					?	?			Davenport, and 4 miles below Hamden.		Visé, Lives, Chokier, Tournay; Ratingen, Bolland, Eng.; Isle of Man; Sable.	Min. conch., pl. 269, figs. 1, 2. Kon. Desc., p. 267, pl. 18, fig. 1.
160	Iowensis.									Iowa River.			Tab. III., fig. 1.
161	pennatus.									Iowa River.			Tab. III., figs. 3 and 8.
162	Cedarensis.									2½ miles below Rockingham.			Tab. III., fig. 5.
163	(S. undet.)									" " "			Tab. III., fig. 9. Allied to S. heteroclytus (Cyrthea Hispania) and S. muralis.
164	triplicatus.										Near Weston, Mo. River.		Stansbury's Exp. Great Salt Lake, p. 410, pl. 4, fig. 5.
165	inequicostatus.									Missouri River? Iowa?			Tab. V., fig. 6.

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	BRACHIOPODA (continued.)																		
166	Spirifer striatus.													*	*	Keokuk Rapids of the Mississippi; Oquaka; Burlington; Marshall Co., Iowa.	Hardin and Jefferson Counties, Ky.; Floyd Co., Ind.; Rockport, Mo.	Visé; Ratingen; Kildare and Cork, Ir'd; Derbyshire; Ural.	Sow. Min. Conch., p. 125, pl. 270. Also in S. Am., at Bolivia, Yarbichambi.
167	striatus?												*			Upper Rapids Miss. River.			The Spirifer of the Upper Rapids of the Miss. has fewer and more prominent ribs, and the mesial fold larger. It may be a distinct species.
168	small var.												*	*		Des Moines River.	Bellevue; Keg Creek; Little Platte.	Soiwa.	Tab. V., 4. Geol. Beo. Key, 1846, p. 231, pl. 8, fig. 3.
169	fasciger?													*					
170	cuspidatus.													*		Keokuk Rapids of the Miss.		Tournay; Liege; Sable; Derbyshire, near Bristol; Bolland; Barton, &c., &c.	Phil., pl. 9, figs. 1-4. Kon. Desc., p. 243, pl. 14, fig. 1.
171	integricosta.													*		" " "	Jefferson County, Ky.	Bolland; Northumberland.	Phil. Gel. York, p. 219, pl. 10, fig. 2. S. furcata. M'Coy.
172	attenuatus?													*	*	Skunk River; Keokuk Rapids Miss.	Floyd Co., Ind.	Near Dublin.	Tab. III. A. fig. 8, and Tab. V., fig. 5? Min. Conch., p. 493, figs. 3, 4, 5.
173	inequicostatus.													*		Skunk River.	Charbonniere, Mo.; Clarke and Floyd Counties, Ind.	Bolland; Visé.	Min. Conch., p. 151, pl. 493, figs. 1 and 2.
174	lineatus?														*				
175	Hanstrum.													*?	*?	Keg Creek; Fort Kearney; Morgan's Island, Mo. River.			
176	rotundatus.													*		Keokuk Rapids.		Visé; Tournay; Middleton; Kildare; Bolland; Limerick.	Sow., 1825, V., p. 89, pl. 461, fig. —. Phil. Geol. York, p. 218, pl. 9, fig. 17.
177	var. semiovalis.													*		" "			
178	ligus.												*			2½ miles below Rockingham.			Tab. III., fig. 4.
179	euruteines.											*	*			Pine Creek; Davenport; below Rockingham; New Buffalo; Rapid Cr. Wapsinonox.	Columbus, Ohio; Charleston Landing, Ind.; Falls of the Ohio.		Tab. III., figs. 2 and 6.
180	(Sp. undet.)												*			Pine Creek, bel. Rockingham.			
181	Orthis bellarugosa.			*												Mineral Point; Ft. Atkinson.	Trenton Limestone, N. Y.		Proc. Aca. Nat. Sci., 1843, p. 33; Hall's Pal., p. 118, pl. 32, fig. 3.
182	(N. S.)			*												Mendota.			
183	testudinaria.			*		*										Near Savannah; Elkader; Prairie du Chien; Big Spring.	Tenn., Kentucky, Ohio, Indiana, New York, and Canada, at various localities.	Caradoc Sandstone of Eng.; Angers, Fr.	Tab. II., figs. 6, 7, 14, 15. Mur. Sil. Sys., pl. 20, figs. 9, 10, p. 640. Hall's Pal., p. 117, pl. 32, fig. 1.
184	cuneata.												*			New Buffalo.			Tab. III., fig. 10.
185	sinuata?.			*												3 miles above Savannah.	Cincinnati, Oxford, O.; Maysville, Ky.; Madison, Ind.		Hall's Pal., p. 128, pl. 32; B, fig. 2. O. occidentalis?
186	(S. undet.)			*												" " "			
187	resupinata.												*			3 miles below Rockingham; Iowa River; Cedar River; Wapsinonox.	Tully, N. Y.	S. Dev.; Barton.	T. and S. resupinata. Phil. Geo., York, p. 220. Phil. Pal. Fos., p. 67, fig. 115. Hall's Geo. Rep., 1843, p. 215, fig. 2.

188	Orthis disparilis?			*						Mineral Point; Fort Snelling; Agency, Turkey River.	Cincinnati.		Tab. II. B, fig. 23. Proc. Acad. Nat. Sci., Phil., 1843, vol. 1, p. 333.
189	(N. S.)			*						Agency, Turkey River.			Tab. II. B, fig. 11.
190	tricenaria.			*						Turkey River; Falls of St. Anthony; Prairie du Chien; Mineral Point.	Middleville.		Proc. Acad. Nat. Sci., Philad., 1843, vol. I., p. 333. Hall's Pal., p. 121, pl. 32, fig. 8.
191	perveta.			*						Mineral Point District.			Proc. Acad. Nat. Sci., Philad., 1843, vol. I., p. 333. Hall's Pal., p. 120, pl. 32, fig. 5.
192	subæquata.			*						" " "			Hall's Pal., p. 118, pl. 32, fig. 2.
193	(N. S.)						*			Near N. Buffalo.			
194	subquadrata.			*						Near Agency, Turkey River.	Cincinnati, O.		Proc. Acad. Nat. Sci., Philad., 1843, vol. I., p. 333. Hall's Pal., p. 118, pl. 32, fig. 2.
195	occidentalis?			*						Above Savannah.	Madison, Ind.		Tab. II. B, fig. 20. Hall's Pal., p. 127, pl. 32, A and B.
196	(S. undet.)						*			N. Buffalo.			Allied to O. umbraculum. Kon. Desc., pl. 13, fig. 7.
197	umbraculum.							*?	*?		Keg Creek, Mo. River; Knobs K.; White Cr. Springs, Tenn.; Clarke Co., Ind.		Tab. V., fig. 11. Spirifer senilis. Orthis divaricata. Phil's Geo. York, p. 216, pl. 9, fig. 5.
198	(N. S.)						*			N. Buffalo.			
199	Michelini.							*		Burlington.	Knobs, Ky.; Clarke Co., Ind.		Kon. Desc., p. 228, pl. 13, fig. 8.
200	crinistria.							*		Keokuk Rapids.	Morgan's Island.		O. quadrata, M'Coy. Spirifer crinistria. Phil's Geo. York, p. 216, pl. 9, fig. 6.
201	(S. undet.)								*		St. Louis, Mo.		
202	Leptæna planumbona.			*						Miss. River, above Savannah; Falls of St. Anthony.	Cincinnati, Oxford, O.; Madison, Ind.; Maysville, Ky.		Hall's Pal., p. 112, pl. 31, B, fig. 4.
203	(S. undet.)			*						Falls of St. Anthony.			
204	alternata.			*						Above Savannah; Dubuque and Mineral Point District; Prairie du Chien.	Various localities in Ohio, Tennessee, Ky., Ind., and N. Y.; G. L. Winnipeg; Ft. Garry.		Hall's Pal., p. 102, pl. 31.
205	sericea.			*	*					Above Savannah; Falls of St. Anthony; Ft. Snelling; Ft. Atkinson; Big Springs.	Trenton L., N. Y.	Var. loc. of the Caradoc Sandstone of Eng.	Sil. Res., p. 636, pl. 19, figs. 1, 2. Strophomena sericea. L. semiovalis. Hall's Pal., p. 110, pl. 31, B, fig. 2.
206	(N. S.)			*?	*?					Big Springs.			Tab. II. B, fig. 16.
207	deflecta?			*						Near Savannah.			Tab. II. B, 21. Proc. Acad. Nat. Sci., Phil., 1843, vol. I., p. 332.
208	(S. undet.)			*						" "			
209	depressa.						*			Head of Otter Creek.		Wenlock; Dudley; Aymestry.	Dalm., l. c., p. 106. t. i. f. 2. His. Pet. Suc. Sil. Resear., p. 623, pl. 12, fig. 2.
210	(N. S.)			*						Near Savannah.			
211	(N. S.)			*?	*?						Red River N.; Gt. Lake Winnipeg; Quebec.		Tab. II. B, fig. 3.
212	deltoidea.			*						Falls of St. Anthony.	Trenton Falls; Little Falls; Sugar R.		Hall's Pal., p. 106, pl. 31, A, fig. 3. Tab. II. B, fig. 10.
213	recta.			*						Mineral Point District.			Hall's Pal., p. 113, pl. 31, B, fig. 6.
214	(S. undet.)			*							Great Lake Winnipeg.		
215	trilobata.			*						Agency, Turkey River.			Tab. II., figs. 17, 18.
216	(N. S.)			*?	*?					Big Springs.			
217	(S. undet.)			*?	*?					Turkey River.	Fort Garry.		
218	Strophodonta parva.						*			Near New Buffalo.			Tab. III. A, fig. 9.
219	demissa?						*			" " "			Tab. III. A, fig. 14. Leptæna dimissa.
220	(S. undet.)						*			3 miles below Rockingham.			Tab. III., fig. 11, and Tab. III. A, fig. 5.
221	costata.						*			Davenport.			
222	(S. undet.)									Near New Buffalo.			
223	(S. undet.)						*			2½ miles below Rockingham.			
224	Chonetes Iowensis.						*			Iowa River.			Tab. III. A, fig. 7.
225	(S. undet.)						*			" "			Tab. III. A, fig. 17.
226	granulifera.							*			Keg Creek, Mo. River.		Tab. V., fig. 12.
227	nana.						*			3 miles below Rockingham.	Falls of the Ohio; Charleston Landing, Ind.	Voroneje, Russia.	Vern. Rus., 1845, vol. II., p. 245, pl. 15, fig. 12. Kon. Mon., p. 206, pl. 19, fig. 5.

TABLE, CONTINUED.

No.	GENERA AND SPECIES.	PROTOZOIC = SILURIAN ROCKS. Lower. F. 1. Lowest Sandstones of Wisconsin and Iowa = Potsdam Sand'e, N. Y.	F. 2. Lower Magnesian Limestone = Calciferous Sandstone, N. Y.	F. 3, A. Shell-beds = Trenton Limestone, N. York.	F. 3, B. Lead-bearing beds of Upper Mag'n Limestone =	Utica Slate, N. Y.	Hudson River Group.	Upper. F. 3, C. Coralline and Pentamerus beds =	Clinton Group, N. Y.	Niagara Group, N. Y.	Limestones of Cedar and Iowa Valleys = Devonian Rocks = Onondaga Group, N. Y.	Corniferous Group, N. Y.	Hamilton Group, N. Y.	Carboniferous Limestones. Lower Series.	Upper Series.	LOCALITIES IN WISCONSIN, IOWA, AND MINNESOTA.	ELSEWHERE IN THE UNITED STATES AND CANADA.	EUROPE.	REFERENCES, SYNONYMS, AND REMARKS.
	BRACHIOPODA (continued).																		
228	Chonetes variolata?													*			Missouri River.	Shropshire; Tournay; Karova, Wol, Ural, Rus.; S. Amer.; Aust.	Productus variolata.
229	crenulata?													*		Augusta.		Chemay; Couvin; Keldenick.	Kon. Mon., 1848, p. 205, pl. 20, fig. 8. Orthis crenulata of Roem.
230	semiovalis.													*?	*?		Keg Creek, Mo. River.		
231	Laquessiana?												*			3 miles below Rockingham.		Bel.; Spain; Derwick; Rahoran.	Kon. Mon., 1848, p. 198, pl. 20, fig. 6.
232	Productus punctatus.													*		Keokuk Rapids, Miss.; Napoleon.	Bellevue, Little Platte, Mo. R.; Zanesville, O.; Quincy, Kaskaskia, Ill.; Eddyville, Ky.; Flint Ridge, &c.	Visé, Lives, Namur. Bel.; Prikcha, Oka, Ural, Moscow, &c., Rus.; S. Amer.; Kildare; Ratingen; Spain.	Sow. Min. Conch., p. 325. Kon. Mon., p. 228, pl. 12, fig. 2.
233	(N. S.?)													*			Keg Creek, Mo. River.	Var. loc. in Russia.	This species is closely allied to P. cancrini (Kon. Mon., p. 105, pl. 11, fig. 3); but as that is a Permian species, it is probably distinct.
234	marginalis?													*		Below Augusta.		Visé.	Kon. Mon., p. 132, pl. 14, fig. 7.
235	(N. S.)													*?	*?	North River.			
236	Boliviensis.													*			Bellevue; Little Platte.	Bolivia; Yarbichambi; S. Rus.	Pal. S. Am. d'Orb., p. 52, pl. 4, figs. 5–9.
237	lobatus?													*		Skunk River.	Wayne City, Mo. River.	Arran, Otterburn, Harelaw; Visé, Chokier, Lives; Ratingen, &c.	P. Flemingii and longispinus. Kon. Mon., p. 95, fig. 2. Phil. Geol. York, p. 214, pl. 8, fig. 7.
238	flexistria.													*		Keokuk Rapids.		Visé; Kildare; Cosatchi-Datchi, Ural.	Kon. Mon., p. 144, pl. 17, fig. 1.
239	cora.													*		Keokuk Rapids; Augusta; Sweet Home; Des Moines.	Keg Creek, Bellevue, Ft. Kearney, Iowa Point, Mo. River.	Visé, Tournay, Chokier; Ratingen; Yorkshire, Kendal, &c.	Tab. V., fig. 1. Pal. S. Amer. D'Orb., p. 55, pl. 5, figs. 8, 9, 10.
240	Flemingii.													*		Augusta.	Keg Creek; Bellevue; Fort Kearney; Grayson Co., Ky.; Zanesville.	Visé, Tournay, &c., Bel.; Ratingen, Altwasser; Cumberland, Northumberland, &c.	Sow. Min. Conch., p. 155, pl. 68, fig. 2.
241	(S. undet.)													*		Skunk River.			
242	costatus.													*			Keg Creek; Bellevue; Fort Kearney; Wellington, Ky.	Sloboda, Botcharova, Karova, Rus., Eng., Irl.	Sow. Min. Conch., p. 115, pl. 560, fig. 1. Kon. Mon., p. 192, pl. 8, fig. 3.
243	Nebrascensis.													*			Bellevue, Mo. River.		Tab. V., fig. 3.
244	(N. S.)													*			Wayne City, Mo. River.		This small species resembles one from the coal-measures of O.
245	(N. S.?)													*?	*?		Des Moines.		This species resembles P. cora, but is, perhaps, distinct.
246	semireticulatus.																10 m. below Ft. Kearney; Nishnabotna; Ft. Leavenworth; Keg Creek; St. Louis.		Flem., 1828. Kon. Mon., p. 183, pl. 8, fig. 1.
247	carbonarius?													*?	*?		Keg Creek, Mo. River.	Chokier; Prikcha.	Kon. Mon., p. 202, pl. 10, fig. 4.

248	Pentamerus lævis?									Dubuque District.	Springfield, O.	Caradoc Sandstone of England.	Sow. Min. Conch., 1813, p. 28, fig. 2. Mur. Sil. Sys., pl. 19, fig. 9.
249	(N. S.)					?	?			Near Davenport.			Tab. III. A, fig. 11.
250	oblongus.									Makoqueta River, Dubuque District.	Springfield, O.; Clarke, Ind.	Caradoc Sandstone of England.	Report of Survey of 1839, pl. 7, fig. 3. Mur. Sil. Sys., pl. 19, fig. 9.
251	Terebratula (N. S.?)										Bellevue, G. Nemahaw, Little Platte, Mo. River; Kaskaskia, Ill.; Tenn., Kentucky, and Ind.		Spec. from Mo. River, intermediate between T. plano sulcata and Roissyii.
252	serpentina?									Skunk and North Rivers.			Tab. III. A, fig. 13.
253	lamellosa.									Keokuk Rapids.		Visé, Tournay, Bel.	Kon. Desc., p. 299, pl. 20, fig. 5.
254	Roissyii.									" "	Greenville, Terre Haute, &c., Ind.; Knobs, Cloverport, Ky.	Tournay, Bel.; Yaouza, Rus.	Kon. Desc., p. 300, pl. 20, fig. 1.
255	striatoplicata.										G. Nemahaw, Morgan's Island, Mo. River.		Not yet figured.
256	sacculus.									Des Moines River.	Bellevue, Mo. River.	Tournay; var. loc. in England and Ireland; Peredki, Altai. Blankenheim.	Kon. Desc. Foss. of Bel., p. 293, pl. 20, fig. 3. Also in Dev. strata of Barton.
257	(S. undet.)									" "			
258	(S. undet.)				?	?					L. Fort Garry.		Tab. II. B, fig. 18.
259	(S. undet.)									Near N. Buffalo.			Tab. III. A, fig. 15.
260	(S. undet.)									2¼ miles below Rockingham.			Allied to T. Versifofii.
261	Wilsoni.									Parkhurst.		Aymestry, Dudley; Gothland; Prague; Russia.	T. lacunosa. Wah. Mur. Sil. Sys., p. 615, pl. 6, fig. 7. In central part of Ludlow.
262	subtilita.							?	?	Des Moines.	Weston, Mo. River.		Stansbury's Ex. G. Salt L., p. 409.
263	Atrypa comis.									Above Rockingham.			Tab. III. A., fig. 4.
264	reticularis.									Forks of Cedar River; near Rockingham; New Buffalo; Shell Rock; Pine Creek.			A. prisca. Terebratula reticularis.
265	aspera.					?				Iowa River.			Variety? of reticularis.
266	(N. S.)									" "			Tab. III. A, fig. 1.
267	hemiplicata.			?						Big Springs, Turkey River.	Middleville, Waterton, N. Y.		Hall's Pal., p. 144, pl. 33, fig. 10.
268	modesta.									Above Savannah.	Cincinnati, Oxford, O.; Madison, Ind.; Frankford, Maysville, Ky.; Trenton, N. Y.		Producta modesta, Say. Hall's Pal., p. 141, pl. 33, fig. 15. In the Utica Slate, and upper part of shaly Trenton Limestone.
269	capax.									Above Savannah; Prairie du Chien; Mineral Point District.	Central part of Trenton Limestone, N. Y.; Madison, Ind.; Davidson Co., Tenn.; Frankfort, Ky., &c.		Jour. Acad. Nat. Sci., 1839, p. 264, pl. 14, fig. 21. A. increbescens. Hall's Pal., 1847, p. 146, pl. 33, fig. 13. Terebratula capax.
270	concentrica.									Pine Creek, and near Rockingham.	Eighteen Mile Creek, N. Y.; Falls of the Ohio.		Bronn. Lethea. Geo., Tab. II., fig. 14? Trigonotrata oblata? Hall's Pal., p. 198, fig. 5.
271	concinna?									Rapid Creek; Fairport.	Moscow, N. Y.		Hall's Geo. Rep., p. 200, fig. 3.
272	Obolus Appolinus.									Miss. R., below Mt. Island.		L. Ladoga; Rus.	Vern. Rus. et Ural, T. III., pl. 19, fig. 3.
273	Lingula prima?									Falls of St. Croix.	Essex, Potsdam Sandstone, N. Y.		Tab. I. B, figs. 2 and 10. Hall's Pal., p. 3, pl. 1, fig. 2.
274	antiqua.									" "	Hammond, N. Y.		Tab. I. B, figs. 7 and 10. Hall's Pal., p. 3, pl. 1, fig. 3.
275	pinnaformis.									" "			Tab. I. B, figs. 4, 6, 8.
276	ampla.									Mt. Island, Miss. River.			Tab. I. B, fig. 5.
277	quadrata.									Near Dubuque.			Tab. II. B, fig. 8.
278	(S. undet.)										L. Ft. Garry, Red River N.		
279	(S. undet.)				?					Iowa.			
280	Orbicula prima.									Falls of St. Croix.			Tab. I. B, figs. 13, 17, 19.
	FORAMINIFERA.												
281	Selenoides Iowensis.			?	?					Dubuque District.			Tab. II. B, fig. 13.
282	(S. undet.)			?	?					Turkey River.			
283	Fusulina cylindrica.									Near St. Joseph's, Mo. River.	Flint Ridge, Ohio; near Fort Kearney, Bellevue, Mo. R.	Rus. and Ural.	
	POLYPARIA.												
284	Catenipora escharoides.									High grounds in the Dubuque District.	Falls of the Ohio; Beargrass; Charleston Landing, Ind.; Clinton; Niagara; near Gt. Lake Winnipeg.	Essex. Gothland, &c. Aymestry and Wenlock Limestone.	Halysites of Fisher. Said to have priority, but not so good a name. Rep. of Survey of 1839, pl. 7. Goldf. Pet., p. 74, tab. 25, fig. 4.

TABLE, CONTINUED.

No.	GENERA AND SPECIES.	PROTOZOIC = SILURIAN ROCKS. Lower. F. 1. Lowest Sandstones of Wisconsin and Iowa = Potsdam Sand'e, N. Y.	F. 2. Lower Magnesian Limestone = Calciferous Sandstone, N. Y.	F. 3, A. Shell-beds = Trenton Limestone, N. York.	F. 3, B. Lead-bearing beds of Upper Mag'n Limestone =	Utica Slate, N. Y.	Hudson River Group.	Upper. F. 3, C. Coralline and Pentamerus beds =	Clinton Group, N. Y.	Niagara Group, N. Y.	Limestones of Cedar and Iowa Valleys = Devonian Rocks = Onondaga Group, N. Y.	Corniferous Group, N. Y.	Hamilton Group, N. Y.	Carboniferous Limestones. Lower Series.	Upper Series.	LOCALITIES IN WISCONSIN, IOWA, AND MINNESOTA.	ELSEWHERE IN THE UNITED STATES AND CANADA.	EUROPE.	REFERENCES, SYNONYMS, AND REMARKS.
	POLYPARIA (continued).																		
285	Favosites Gothlandica.																		Calamopora. Goldf., p. 78, tab. 26, fig. 3.
	var. basaltica.									*						High grounds in the Dubuque District.	Falls of the Ohio, Beargrass, Charleston Landing, Ind.; Clinton, Niagara; near Gt. L. Winnipeg.	Eifel, Gothland.	No essential difference between F. Gothlandica and F. basaltica.
286	polymorpha.											*				Iowa River; Rapid Creek.	Falls of the Ohio; Charleston Landing.	Eifel; Hartz; Bensberg; Namur; Elderfield; Prussia; Paffrath.	Goldf., p. 79, tab. 27, fig. 2. D'Orb calls the Dev. F. polymorpha, cronigera.
	var. ramosa.															Davenport.			
287	spongites.											*				Iowa River and Davenport.	" " "	Bensberg; Dudley.	Goldf., p. 80, tab. 28, fig. 1.
288	(S. undet.)													*?	*?		10 miles below Ft. Kearney.		Allied to F. (Calamopora) scabra. Kon. Desc., p. 9, pl. B, fig. 1.
289	Chætetes lycoperdon.			*												Near Savannah.	Cincinnati, O.; Madison, Ind.; Maysville, Frankfort, Ky.; Davidson and Maury Counties, Tenn.		Hall's Pal., p. 48, pl. 12, figs. 3 and 5.
290	(Sp.?)											*				Rapid Creek.			Though this occurs in rocks of Dev. date, it seems nearly allied to C. lycoperdon.
291	capillaris.														*		Missouri River, below Fishing River; Posey Co., Ind.		
292	Astræa ananas.											*				Iowa River; Davenport.		Namur; Eifel; Ferques.	Lithostrotion and Cyathophyllum ananas. Goldf., p. 16, tab. 19, fig. 4. Rep. of Survey of 1839.
293	pentagona.															" " "		Namur.	Lithostrotion, (Cyathopyllum) pentagonium. Goldf. p. 60, tab. 19, fig. 3.
294	Stromatopora concentrica.											*				" " "	Near Nashville, Tenn.	Eifel.	Goldf., p. 22, tab. 8, fig. 5.
295	polymorpha.											*				" " "		Bensberg.	Goldf., p. 13, tab. 5, fig. 6.
296	(N. S.?)											*				" " "			
297	(N. S.?)												*			Winnebago Reserve.			
298	capitata.											*				Iowa River.			
299	Cyathophyllum turbinatum.									*			*			Rapid Creek and Dubuque District.		Eifel.	Goldf., p. 56, tab. 16, fig. 8.
300	ceratites.												*			" " "		Eifel; Bensberg.	Goldf., p. 56, tab. 17, fig. 2.
301	flexuosum?													*	*	Keg Creek, Mo. River.			Tab. IV., fig. 3.
302	dianthus?												*			" " "			
303	(S. undet.)															Davenport.			
304	fungites.													*		Keokuk Rapids.		Visé; Bolland; Stradone.	Tab. IV., fig. 4. Kon. Des., p. 24, pl. D, fig. 2.
305	helianthoides.									*						Dubuque District.	Lake Huron.		Report of Survey of 1839, pl. 13, fig. 1.
306	vermiculare?											*				Iowa River.		Eifel; Ferques; Plymouth; Ogwell.	Tab. IV., fig. 2. Cystiphyllum vermiculare.
307	plicatum.												*			3 miles below Rockingham.		Sweden.	Goldf., p. 59, tab. 18, fig. 5.
308	Caryophyllia fasciculata.												*			Near Davenport, Iowa.			Lithodendron fasciculatum. P. Kon. Desc., p. 17, pl. D, fig. 5.

309	Cystiphyllum vesiculosum.	Rapid Creek, Iowa.		Eifel.	Goldf., p. 58, tab. 17, fig. 5; tab. 18, fig. 1.
310	Cyathopora Iowensis.	Near Rockingham.			Rep. of Survey of 1838.
311	Columnaria (S. undet.)	Parkhurst.			
312	Cellepora (N. S.)	Near Rockingham.			
313	(N. S.)	" "			
314	Fenestella Milleri?	" "			Tab. III. A, fig. 21.
315	(Sp. undet.)	" "			Tab. III. A, fig. 16.
316	Gorgonia repisteria.	" "			Tab. III. A, fig. 19. Kon. Des., p. 6, pl. A, fig. 4.
317	fastuosa?		Mo. River, below St. Charles.		Kon. Des., p. 7, pl. A, fig. 5. Retepora repisteria.
318	Retepora.	Des Moines River.	Tennessee.		
319	prisca.	Near Rockingham.	Mo. River, below St. Charles.	Eifel.	Goldf., p. 103, tab. 36, fig. 9.
320	? Archimedes.	Keokuk Rapids, Des Moines, &c., &c.	Leavenworth, Ind., &c.		Tab. IV., fig. 1.
321	Lithostrotion basaltica.	Sweet Home, Des Moines.			Tab. IV., fig. 5.
322	subcylindriformis	Sugar Creek, Iowa.			Tab. IV., fig. 6. This may be only a variety of fig. 5.
323	floriforme.	" " "	Indiana and Kentucky.		
324	Cosinopora sulcata.	Dubuque and Mineral Point Districts.			Report of Survey of 1839, pl. 7, fig. 5.
325	Strombodes pentagonus	Dubuque District	Lake Huron.		Sil. Jour., p. 1847. Goldf., p. 62, tab. 21, fig. 3.
326	Aulopora serpens.	" "		Eifel: Bensberg.	Goldf., p. 82, tab. 29, fig. 1. Report of Survey of 1839, pl. 14, fig. 2.
327	Syringopora reticulata	Keokuk Rapids.		Olne.	Goldf., p. 76, tab. 25, fig. 8.
328	lineata?	Dubuque District.			Report of Survey of 1839, pl. 13, fig. 2.
329	Sarcinula costata.	" "			Report of Survey of 1839, pl. 14, fig. 12. Goldf., p. 73, tab. 24, fig. 11.
330	Porites pyriformis	Dubuque District.			

TABLE OF EQUIVALENCY OF THE GEOLOGICAL FORMATIONS OF WISCONSIN, IOWA, AND MINNESOTA.

WISCONSIN, IOWA, AND MINNESOTA.	MIDDLE AND WESTERN STATES, AND CANADA.	PENNSYLVANIA.	STATE OF NEW YORK.	GREAT BRITAIN.
	Coal-measures of Ohio.	No. XIII.		Coal-measures.
Coal-measures of Iowa?	" " Michigan?	No. XII.		
Conglomerates and ferruginous grits of Iowa R.?				Millstone grit.
Upper Carboniferous Limestone.				Upper Scare, or Yoredale Series.
Lower " "	Fine-grained Sandstone of the Knobs.	No. XI.		Lower Scar Limestone.
		No. X.	Old Red Sandstone.	Old Red Sandstone.
		No. IX.	Portage and Chemung Group.	Devonian System, in part.
	Black bituminous shale of the Knobs, and Goniatite Limestone of Indiana.	No. VIII.?	Genesee Slate.	" " "
Upper coralline and shell-beds of Cedar Valley.		No. VIII.	Hamilton Group.	" " "
		"	Marcellus Slate.	" " "
	Shell-beds of the Falls of the Ohio.	"	Corniferous Limestone.	" " "
Lower Coralline beds of Cedar Valley?	Coralline-beds " " "	"	Onondaga Limestone.	" " "
		No. VII.	Oriskany Sandstone, Cauda-galli and Schoharie grit.	
				Ludow Rocks, including Aymestry Limestone.
	Limestone of Little Traverse Bay.		Pentamerus and Delthyris Shaly Limestone.	
	Mackinaw Limestone.		Onondaga, Salt Group, and Water Limestone.	
Geodiferous beds of Lake Michigan.				
Waukeshaw Limestone.		No. VI.	Niagara Group.	Wenlock Rocks.
Coralline and Pentamerus beds of the Upper Magnesian Limestone, F. 3, C.				" "
	Oolitic Iron-ore of Ohio and Tennessee.	No. V.	Clinton Group.	
Place of supposed Red Sandstone of Lapham?	Medina Sandstone of Canada.		Medina Sandstone.	
		No. IV.	Gray Sandstone and Oneida Conglomerate.	
Lead-bearing beds of the Upper Magnesian Limestone, F. 3, B.	Shales and slates in Canada = Lorraine shales of N. Y.	No. III.	Utica Slate and Hudson R. Group.	Middle part of Lower Silurian System, or Caradoc Sandstone and Llandeilo Flags of Murchison.
	Bluish-green Limestone.			
Shell-bed F. 3, A.	Blue Limestone of Ohio in part.	No. II. in part.	Trenton and Black River Limestone.	
			Bird'seye and Chazy Limestone.	
Upper White Saccharoid Sandstone, F. 2, C.				
Lower Magnesian Limestone, F. 2, A and B.	Siliceous and Calciferous Limestones.	No. II. in part.	Calciferous Sandrock.	
Lower light-coloured quartzose sandstone, F. 1.	Upper Gray Sandstone, and	No. I.	Potsdam Sandstone.	
Red argillaceous and ferruginous sandstones, and Shales of Lake Superior.	Variegated Sandstones of Pictured Rocks.			

INDEX.

THE END.

NOTICE.

It is recommended to all those who desire to preserve the large geological map accompanying this Report, to cut it out and paste it on linen. The mode of executing this operation successfully is as follows:—Damp the linen; stretch it firmly on a flat board by tacking it down; paste the back of the map with smooth, well-made flour paste, applied with a large, stiff, flat brush; lay the pasted surface on the stretched linen, taking care to exclude all air from between the surfaces, by holding the edges of the sheet up, and allowing its centre first to come in contact with the linen; press the two surfaces together from the centre towards the sides and edges, through the medium of a cloth.